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Smokes and Obscurants: A Health and Environmental Effects Data Base Assessment

A First-order, Environmental Screening and Ranking of Army Smokes and Obscurants

Phase I Report

Joseph H. Shinn, Stanley A. Martins,
Patricia L. Cederwall, and Lawrence B. Gratt

March 1985

Lawrence Livermore National Laboratory

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An initial environmental screening and ranking is provided for each Army smoke and obscurant (S&O) depending on smoke type and smoke-generating device. This was done according to the magnitude of the impact area, the characteristic environmental concentration, the relative inhalation toxicity, the relative toxicity when ingested by animals, the aquatic toxicity, the environmental mobility when freshly deposited, and the ultimate mobility and fate in the environment. The major smoke types considered were various forms of white phosphorus (WP), red phosphorus (RP), hexachloroethane-derived smokes (HC), fog oil (SGF-2), diesel fuel smokes (DF), and some infrared obscuring agents (IR).

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EXECUTIVE SUMMARY

This report provides an initial evaluation and integration of a comprehensive health and environmental studies data base of Army smoke and obscurant (S&O) material. The objective was to support the U.S. Army's need for environmental assessments. In addition this data base should provide information for environmental impact of S&O devices by various Army agencies for field test, evaluation, and training. The procedure utilized was a first-order screening and ranking of the major smoke types and smoke-generating devices. This was done for each according to the magnitude of the impact area, the characteristic environmental concentrations, the relative inhalation toxicity, the relative toxicity when ingested by animals, the aquatic toxicity, the environmental mobility when freshly deposited, and the ultimate mobility and fate in the environment.

The major smoke types considered were various forms of white phosphorus (WP), red phosphorus (RP), hexachloroethane-derived smokes (HC), fog oil (SGF-2), diesel fuel smokes (DF), and some infrared obscuring agents (IR), EA-5763 and EA-5769. Various properties of the smoke-generating devices were taken into account, such as the type of delivery (either bursting/ instantaneous or diffusing/continuous), effective fill weights, and initial cloud volumes in air. It was found that except for an RP bomblet, all bursting devices (grenades, mortars, guns, rockets, and howitzers) have a relatively small impact on ground areas but diffusing devices (smoke pots, diesel fuel exhaust, and fog oil generators) could affect larger areas, tens to hundreds of acres.

The characteristic environmental concentrations of devices were found to be highest from grenades, but these also were very localized. HC diffusing (howitzers) and WP bursting (mortars, guns, rockets, and howitzers) were also devices with high environmental concentrations. The acute (one-hour) inhalation toxicities were highest in HC smoke followed by IR obscurants, WP, RP, DF, and fog oil (SGF-2). We developed an air concentration quotient (C.Q.) for relative inhalation toxicity of various devices and found that grenades (IR and RP) were potentially the most dangerous. The artillery-produced smokes (mortars, guns, rockets, and howitzers) were significantly toxic when the S&O was HC and WP. The phosphorous smokes from wedges (RP/W and WP/FW) were far less toxic than

smokes from other devices. HC smoke pots were on the borderline of inhalation toxicity while fog oil (SGF-2) and diesel fuel had insignificant toxicity.

The foliage ingestion quotient (F.I.Q.) was used to screen one potential ecological effect. This indicated that the WP, RP, IR, and HC smokes were significantly toxic to animals when deposited on foliage they consumed. Another potential ecological effect was addressed by the use of an aquatic toxicity quotient (A.T.Q.). Here the HC smoke and IR obscurant (EA-5763 and EA-5769) were found to be toxic to fishes while fog oil and diesel fuel were borderline in their aquatic toxicity. WP and RP smoke types had insignificant A.T.Q.s.

Environmentally transformed by-products of S&O materials were screened for water solubility in an effort to predict their fates. In freshly deposited smokes, the WP, RP, and HC inorganic forms were found to be highly mobile, but the water soluble (aromatic) organic components of SGF-2 and DF were only slightly mobile. Substances in IR smokes were found to be more or less immobile. After a few weeks, transformations usually decreased the mobility of WP, RP, and HC by more than three orders of magnitude. The WP and RP smoke products should end up in phosphate pools. DF by-products increase in mobility and become susceptible to biodegradation. HC in soil became very immobile. The ultimate fate of HC in soil or water is partly to join the large chloride pools and partly to become a component of less mobile, pH-regulated, zinc complexes. Bioavailability and potential toxicity of P and HC smokes would then decrease in the long term.

In conclusion, this screening and ranking procedure has determined what and when smoke-producing devices could be environmental problems and to what degree relative to each other. In general, the devices impacting the largest area (DF and SGF-2) had insignificant environmental effect due to dilution, while those with the least area of impact (grenades) had largest environmental effect. We found that by considering the inhalation, foliar ingestion, and aquatic toxicities, combined with the area of impact, the environmentally most troublesome devices were the HC smoke pot, followed by the HC grenade and HC artillery and, in fourth place, the IR grenade. All other devices were orders of magnitude less important environmentally.

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CONTENTS

BACKGROUND AND OBJECTIVES

The U.S. Army has developed smokes and obscurants (S&O) for its needs in the battlefield since World War I. The inventory of S&O at present consists of materials derived from phosphorus (P), hexachloroethane (HC), fog oils (SGF-2), diesel fuel (DF), and new infrared (IR) screening agents. Recent Army S&O development programs have resulted in improvements in materiel performance, adaptation of S&O material to changed battlefield requirements, invention of new S&O agents, and requirements for safe and environmentally acceptable products. The U.S. Army Medical Bioengineering Research and Development Laboratory (USAMBRDL) has responded to the Army's needs with health and environmental studies of S&O material. Such studies serve to support the numerous field testing, evaluation, training, and supply agencies which must handle and utilize the S&O material in a safe and environmentally sound manner.

While the CRDC "Programmatic Life Cycle Environmental Assessments"[1-5] have listed and summarized many key studies of smokes and obscurants, the extensive Army research effort on the health and environmental effects has never been integrated into a comprehensive evaluation. To fill this gap, USAMBRDL has sponsored the present data base compilation and assessment.

The purpose of this report is to provide an initial evaluation and integration of the comprehensive data base on health and environmental studies of smokes and obscurants. The methodology consisted of a screening and ranking procedure that used a data base that had been extracted from numerous reports and other literature. The most labor-intensive effort was to transform and quantify data from our literature survey study results into a computer-compatible data base management system. A substantial contribution of this study therefore was the bibliographic file listed in this report. In order to accomplish the data base assessment within a reasonable time and with "milestone" reports, the effort was planned in phases. Phase I Data Base Assessment was extensive, but shallow, intending to encompass all S&O and to provide to interested users a screening and ranking system. Phase II would deal with intensive evaluations and fill knowledge gaps identified in Phase I.

APPROACH

Conclusions and data from numerous reports were evaluated and entered into a machine-processable data base (data base management system). The data were divided into several categories. These include S&O device characteristics relevant to environmental issues, physical/chemical properties, and various health and environmental quantities described later. Cross-indexing was provided to permit machine searches traceable to the original articles according to an accession number. The subdivisions of the above categories evolved into a limited set as the evaluation and comprehension of the data base proceeded. A major consideration in this evolutionary process was the guideline of Phase I objective--to provide an initial screening and ranking of first order. The difficulty in adhering to this objective was to decide which information was more properly placed in Phase II; obviously, some intensive assessment was necessary to accomplish Phase I. Consequently, a minor effort was expended toward the Phase II goal--to provide an intensive S&O assessment and to fulfill and identify research needs.

ENVIRONMENTALLY RELEVANT S&O DEVICE CHARACTERISTICS

The first consideration was to define broad categories of smoke type. This is somewhat artificial because a given composition may be modified within a smoke type, and because there may be operational needs to combine smoke types to achieve a particular smoke/obscurant effect. <u>We did not consider the environmental issues of combined smoke types in this study</u>. The categories of smoke type included in this report are also limited to those currently important, which excludes outmoded S&O, S&O not recommended for further use, and some S&O material in an early stage of research and development. The categories included are given in Table 1, Army Smoke Types for Environmental Screening.

The smoke materials listed (see Table 1) include all the S&O likely to be in an inventory. Phosphorus smokes have evolved into prominence. HC smokes are being phased out, but are common in smoke pots. Fog oil smoke generators should remain in prominence for protection of secured positions (rear area of the battlefield), but SGF-2 should be the only oil recommended

TABLE 1. ARMY SMOKE TYPES FOR ENVIRONMENTAL SCREENING.

A. Phosphorus smokes (P)
   1. White phosphorus (WP)
      White phosphorus/felt wedges (WP/FW)
      Plasticized white phosphorus (PWP)
      White phosphorus wicks (WPW)
   2. Red phosphorus (RP)
      Red phosphorus/butyl rubber (RP/BR)
      Red phosphorus wedges (RPW)

B. Hexachloroethane smokes (HC)

C. Fog oil (SGF-2)

D. Diesel fuel (DF)

E. Infrared (IR) smokes (EA-5763 and EA-5769)

for use. Diesel fuel would be the common smoke type used on moving vehicles. IR smokes are new, but only two are included in this report (EA5763, EA5769), and their composition is revealed here only as oily brass particles.

The devices used as delivery systems for smoke and obscuring agents are usually also the containers for storage and transport of the smoke type. The exceptions are the fog oil and diesel fuel normally stored and transported in bulk containers, and pumped into a heated, forced-air chamber when utilized to generate smoke. The device characteristics that were applied to health and environmental screening were the effective fill weight (Q), the minimum area of impact (A), the burn time (t_B), the average rate of burn (dQ/dt) in the case of continuous smoke generators, and the minimum vertical extent (h) of the smoke. Details of the smoke concentration distribution, median particle size, and size-distributions were not used in the screening. Estimations of effects such as acute inhalation response and concentrations in the environment resulting from deposition, were determined as first-approximations by the derivation of suitable quotients or indices.

The first-order estimates were not considered extremely limiting for these ranking purposes. Inhalation response to particle-size is about the same for all smokes because their physical sizes will be about the same in

order to be effective obscurants. To a good approximation, the fraction of suspended mass retained, for example in the deep lung (pulmonary) region, would be the same for all S&O agents. Furthermore, physically meaningful indices were defined.

The effective fill weight (Q) divided by the minimum area of impact (A) defines the upper bound of deposition that could occur over the area under any circumstances:

$$\text{Maximum available deposition} = \frac{Q}{A}. \tag{1}$$

Carrying this argument further, dividing the effective fill weight (Q) by the minimum effective volume (Ah) defines <u>the maximum environmental air concentration (C) averaged over the minimum area of impact (A), which could occur</u>, e.g., from bursting devices:

$$C = \frac{Q}{Ah}. \tag{2}$$

The first difficulty is in determining A. The minimum impact area is important, however, because it can serve as a ranking index in itself. <u>The minimum area of impact is usually small and serves to demonstrate that each device has a small potential ecological cost when viewed on a global scale</u>. Consequently, ranking the devices by impact area (A) was a useful first-order exercise. In the case of bursting devices C must be defined differently as derived next.

For bursting devices, the material is spread instantaneously and can be viewed as having a Gaussian distribution in the second instant, at which time atmospheric diffusion begins. The area A_B can be estimated for bursting munitions as a circle of radius (R) containing 95% of the material, which has Gaussian width σ_y and height σ_z:

$$R = 2\,\sigma_y, \tag{3}$$

$$A_B = 4\pi\,\sigma_y^2, \tag{4}$$

$$h = \sigma_z. \tag{5}$$

We found that for nearly all bursting devices the parameters σ_y and σ_z were available from the data base, and for approximation purposes:

$$\sigma_z = \sigma_y 3. \tag{6}$$

Hence, the maximum concentration (C_B), given for bursting devices in equation (2) was calculated from the given Q in the data base and equations (4) through (6).

For burning munitions such as smoke pots, a different approach was used because a burning device would be diluted and diffused by the wind during the burn. The minimum impact area (A') for burning devices was defined as the area covered in the horizontal plane by a substance diffusing under stable conditions (Pasquill stability category F) with calm conditions (wind speed 0.5 m/s) during the burn time. For all burning devices the burn time (t_B) (usually several minutes) was available from the data base with the exception of fog oil and diesel fuel continuous generators. For the continuous generators a convenient burn time of one hour was used, and the burn rate (dQ/dt) was considered constant so that calculation of Q_c for continuous release was the product of dQ/dt and t_c, where t_c = 1 hour:

$$Q_c = \frac{dQ}{dt} t_c . \tag{7}$$

The minimum impact area for continuous releases (A') depended upon the plume width (σ_y), plume height (σ_z), wind speed (u), and burn time (t_B):

$$\sigma_y = 0.04 X, \tag{8}$$

$$\sigma_z = 0.016X, \tag{9}$$

$$X = u\, t_B , \tag{10}$$

$$u = 0.5 \text{ m/s}. \tag{11}$$

where relations (8) and (9) are the Briggs' estimates for close-in diffusion under calm winds in F stability category from the "Handbook on Atmospheric Diffusion."[6] The minimum impact area (A') for the Gaussian plume is a triangular area containing 90% of the material (see Appendix A) estimated by

$$A' = 2 \pi \sigma_y u t_c , \tag{12}$$

and the average environmental air concentration for diffusing smokes by

$$C_D = Q/A'\sigma_z. \tag{13}$$

Because the definitions of the minimum impact area for bursting (A_B) and for burning (A') devices are different, care should be exercised in their comparison. On the one hand bursting devices have a closely defined impact area, whereas burning devices have a minimum impact area, which was estimated as a worst case diffusion problem that applies realistically only in calm winds at night.

The choice of t_c = 1 hour was made to approximate the times of exposure to fog oil and diesel fuel, but in actual cases it would vary. (Actual times could be adjusted as a multiple of hours.) In quotients to be discussed later, one-hour exposure concentrations were compared to C. This exposure time may seem incongruous to the burn times (t_B) of devices that last only a few minutes. But in that case we envision a puff-like cloud that persists depending on wind speed and could take up to an hour to disperse in very calm winds, a worst case.

CONSIDERATIONS GIVEN TO PHYSICAL/CHEMICAL PROPERTIES OF S&O

A major difficulty was to determine the likely chemical residuals and their physical properties in the environment. We attempted to reconcile the expressions given in the data base for chemical reactions during combustion of S&O devices. It became evident that, particularly for phosphorus and HC devices, there was no way to unify the various results. Excellent laboratory studies that proceded to complete combustion under controlled conditions did not represent well the few field observations of combustion product concentrations. We made our own estimates of the critical components and their ultimate fates, to the degree justifiable for a first-order ranking and verifiable where possible. This list of residuals was explored for chemical/physical properties.

Properties considered useful for first-order assessments were the octanol-water partition coefficient, the solubility in water at normal

temperatures, the vapor pressure at normal temperatures, and others. The utility of these properties has been established, for example, in estimating partitioning coefficients for a simplified compartmental model of the environment. These concepts were defined by Laskowski _et al_.[7] for the terrestrial environment in a noteworthy compendium of methods, "Environmental Risk Analysis for Chemicals," edited by Conway.[8] The environmental fate should be evaluated using the pollutant limit values method of Rosenblatt, Dacre, and Cogley[9] in the same book (loc. cit.). We utilized the "Handbook of Chemical Property Estimation Methods" by Lyman, Reehl, and Rosenblatt[10] to determine octanol-water partitioning coefficients, solubilities, and vapor pressure for certain organic fractions identified as constituents in SCF-2 fog oil, and in the middle petroleum distillates found in diesel fuel.

These methods did not lead to a successful ranking of S&O materials in terms of soil adsorption coefficients, volatilization, bioconcentration factors, and biodegradation. The major reason for the incomplete application of the methods and failure to establish preliminary pollutant limit values was the nature of the inorganic constituents in phosphorus and HC smokes. Both of these smokes we found were dominated by highly soluble, very low vapor pressure inorganic products that ultimately transform and lose their identity in large elemental pools within the natural water and soil systems. The utility, and even the meaning, of soil adsorption and volatilization became obscured.

Methods very useful for ranking pesticides and other persistent pollutants were not applicable to S&O chemicals that become part of nutrient cycles or are transformed into bound components of the soil/sediment systems. For example, for pesticides the soil adsorption coefficient is highly correlated to the organic matter concentration, but for phosphoric acid the soil adsorption occurs on clay minerals and depends upon other elemental concentrations.[11,12] The phosphoric acid is transformed into calcium, iron, and aluminum phosphates whose solubility in the water or soil environment depends highly on pH.

<u>The first-order rankings of S&O chemicals for mobility in the environment were by solubility of the initially deposited material as a measure of potential acute deposition effects and by solubility of the transformed products as a measure of potential long-term chronic effects</u>.

HEALTH AND ENVIRONMENTAL INDICATORS

The suspended smoke materials were expected to adversely affect living systems through two pathways. The first was the exposure of mammals to respirable particles that may be toxic via the inhalation pathways. Since all smokes have about the same particle-mass size distributions the respirable fraction would be about the same for each. We ranked the potential acute effect of smoke/obscurant inhalation according to the one-hour lethal concentrations to rats. The choice of rats was made because their inhalation response is similar to humans (although this response is generally less sensitive than mice) and because rats are usually the animals of choice in toxicology bioassay studies.

The method required some estimations, however. The data base contained non-standardized information. We chose the LC_{50} at one-hour (lethal concentration of 50% of the population exposed for one-hour and observed at 14 days following exposure). The data base contained incomplete data such as LC_{20} or LC_{30}, etc., and often data were expressed as doses (concentrations multiplied by time). It is usually assumed that Haber's Law describes inhalation response.[13] That is, the effects are the same for a given combination of concentration and time of exposure as long as the product (Ct) remains constant. We found that the method of Haber's Law (Ct = constant) gave 65% errors in estimating inhalation effects of smokes.

Two studies of relevant inhalation response in rats were found to give the same basic results: a study by Dalbey and Lock[14] using "Phillips Referee-grade" diesel fuel, and a study by Ballou[15] using red phosphorus smoke. We reanalyzed their data and found that LC_{50} values could be calculated from intermediate results LC_X (e.g., LC_{20}, LC_{80}) using the relation:

$$LC_{50} = (LC_X) \exp((50-X)/B), \tag{14}$$

where B is an experimental constant. We found values of B = 60.3 for diesel fuel and B = 57.2 for red phosphorus. These B-values are the same within 3%. Furthermore, Dalbey and Lock's data confirmed that B is not a function of exposure time. Next we found that the LC_{50} time-dependence was statistically highly correlated to exposure time (R^2 = 0.97) by the relation:

$$\log_e (LC_{50}) = -at + b, \tag{15}$$

where a and b are constants for given experiments. From this we derived the interpolation equation at exposure time t_1:

$$(LC_{50})_1 = (LC_{50})_2 \exp [a(t_2 - t_1)], \tag{16}$$

where a is the same constant as in equation (15) and the subscripts refer to two different exposure times, t_2 and t_1. The constant for diesel fuel is $a = 0.239\ h^{-1}$, while $a = 0.295\ h^{-1}$ for phosphorus smoke. The constants were close enough to combine for ranking purposes, and we used this one interpolation scheme (Table 2) for all smokes. (The values in natural logarithms for the other constants, $b = 3.291$ for diesel fuel and $b = 1.706$ for phosphorus smoke, were not used.) <u>Solutions to equations (14) and (16), as given in Table 2, were used to interpolate LC 50 for all smokes and obscurants</u>. The mean deviation from Haber's Law was 65%.

A determination of deposition was made by a common method. We used a deposition velocity concept, with a value of $v_d = 0.1$ cm/sec (3.6 m/h). This is a commonly accepted estimate for particles of unit density in the size range 0.3 to 3 µm diameter.[6,16] Deposition flux (F) was estimated from C (mg/m^3):

$$F = v_d\ C. \tag{17}$$

For ranking purposes we took a typical concentration for smoke of C = 1000 mg/m^3, which was within a factor of three of the range of values computed for WP-devices using equations (2) and (13). Also, typical fog oil concentration values were found to be 15 to 2000 mg/m^3.[17] The deposition of smoke at 1000 mg/m^3 concentration was estimated at 3600 mg/m^2 for a one-hour release, and at one release per day represents a concentration of 48 mg/kg when incorporated into 5 cm of soil and a concentration of 3.6 mg/liter when incorporated into water of 1-m depth. A soil depth of 5 cm represents a zone of soil that is considered well-mixed in natural ecosystems, but typical plow layers for cultivated fields would be 15 cm in depth, reducing this estimated concentration.

TABLE 2. INTERPOLATION TO INHALATION LC_{50} VALUES FOR OTHER PERCENTAGES OF LETHALITY AND OTHER TIMES OF EXPOSURE RELATIVE TO ONE HOUR.

Ratio of LC_{50} relative to given percent lethality		Ratio of LC_{50} at one-hour exposure to LC_{50} at given exposure time, t	
LC_{20}	1.67	t = 2 h	1.3
LC_{30}	1.41	3 h	1.7
LC_{40}	1.19	4 h	2.2
LC_{50}	1.00	5 h	2.9
LC_{60}	0.85	6 h	3.8
LC_{70}	0.71	7 h	5.0
LC_{80}	0.60	8 h	6.6

Estimations of foliar deposition often use the Chamberlain normalized specific concentration (NSC); an example was given by Shinn.[18] Using the accepted NSC value of 30-60 m^2/kg (dry weight of foliage) for a one-hour exposure per day, we obtained an estimate of foliar retention of 100-220 g/kg dry weight for an airborne smoke concentration of 1000 mg/m^3. Direct foliar consumption by cattle would transfer pollutant at 0.020 mg/kg body weight per day per 1 mg pollutant/kg; likewise 0.060 mg/kg body weight for rats.[7]

Smoke product accumulation in cattle would be 2.2-4.3 g/kg each day and in rats 6.5-13 g/kg each day if they were eating foliage exposed to 1000 mg/m^3 for one hour, estimated by the NSC method. The sensitivity of smokes via the ingestion pathway was estimated by the oral LD_{50} for rats, the ingested dose (mg/kg) causing 50% lethality in rats. These data were readily available in the data base. The ranking of smokes for oral toxicity was obtained by dividing the calculated smoke ingested value, 6.5 g/kg, by the LC_{50} for each smoke substance.

Aquatic toxicity was estimated on the basis of the above estimate of water concentration, 3.6 mg/liter, compared to the TLm_{96}, the 50% lethal

concentration for 96-hour exposures of common bioassay fishes. Aquatic ranking of smokes was obtained by taking the ratio of dissolved concentration to TLm_{96}, provided the dissolved concentration was feasible in terms of its solubility in water.

RESULTS

RANKING BY DEVICE IMPACT AREA AND ENVIRONMENTAL CONCENTRATION

As much information as possible was obtained for each device so that each could be ranked on the basis of its particular effective fill weight, impact area, and maximum environmental concentration. The device properties are provided in Appendix B, because of the extent of those data. It was possible to categorize the data, however, and to rank these categories in terms of minimum impact area. The relative importance of each category according to impact area is given in Table 3. The values in Table 3 represent the ranges given for several similar devices within a category, rounded off, and indicate whether the device is diffusing or bursting. (It should be recalled that diffusing and bursting areas are calculated differently, so caution should be exercised.) The general result was that phosphorus devices with wedges (RP/W and WP/FW) and the RP bomblet had the largest areas of the bursting devices. Except for the bomblet, all bursting devices would impact a relatively small area (less than three acres or the equivalent of three football fields). Continuous sources like the smokepots, diesel fuel exhaust systems, and fog oil generators, however, would impact large areas (ten to hundreds of acres).

The determination of environmentally important concentrations (C) of smokes and obscurants estimated by equations (2) or (13), was also done for each device; see Appendix B for details. Just as in the case of the rankings of impact area, it was possible to categorize the data and to rank these categories. The relative importance of each smoke and obscurant category is given in Table 4. We found unexpectedly that grenades, especially IR and RP/BR, produce the highest environmental concentrations, but it should be recalled (Table 3) that these are very local. HC diffusing (howitzers) and

TABLE 3. MINIMUM AREA IMPACTED IN S&O DEVICE CATEGORIES, RANKED.

	Device type	Ground area (m^2)[a]
1.	IR bursting, RP/BR bursting (grenades)	50
2.	WP bursting (mortars, guns, rockets, howitzers)	100-800
3.	HC diffusing (howitzers)	50-1200
4.	HC diffusing (grenade)	1000
5.	RP/W bursting (mortars and howitzers)	1000-11000
6.	WP/FW bursting (rockets and howitzers)	9500-12000
7.	HC and SGF-2 diffusing (smoke pots)	9500-65000
8.	RP bursting (bomblet)	180000
9.	DF diffusing (diesel fuel exhaust, each hour)	300000-800000
10.	SGF-2 diffusing (fog oil generator, each hour)	500000-800000

[a] By comparison, one acre and one football field (U.S.) occupy 4050 m^2 and 4280 m^2, respectively.

TABLE 4. CALCULATED ENVIRONMENTAL CONCENTRATIONS OF S&O DEVICES, RANKED.

	Device type	Concentration (mg/m^3)
1.	RP Bursting (bomblet)	2
2.	DF Diffusing (diesel fuel exhaust, each hour)	10
3.	SGF-2 Diffusing (fog oil generator, each hour)	5-10
4.	WP/FW Bursting (howitzer and rockets)	5-25
5.	HC and SGF-2 Diffusing (smoke pots)	10-110
6.	RP/W Bursting (mortars and howitzers)	25-220
7.	HC Diffusing (grenade)	220
8.	HC Diffusing (howitzers)	450-660
9.	WP Bursting (mortars, guns, rockets, howitzers)	1800-3500
10.	IR and RP/BR Bursting (grenades)	>10000

WP bursting (mortars, guns, rockets, and howitzers) ordnance produce the second highest environmental concentrations, but again over a small area from 100 to 1200 m^2.

RANKING BY INHALATION TOXICITY AND AIR CONCENTRATION QUOTIENT

The inhalation toxicity of smoke and obscurant materials was the primary effect considered from short-term, acute exposures (up to one hour). We ranked the smoke materials as mixtures; that is, the chemical composition of the smoke mixture was not further subdivided for inhalation toxicity ranking. The various smoke types are ranked in Table 5 according to the one-hour LC_{50} for rats.

The LC_{50} values (inhalation) given in Table 5 were each estimated from more than one reference. The LC_{50} value for SGF-2 was estimated from one LC_{20} value[15] and from several studies of similar oils that put limits on the LC_{50} estimate for SGF-2. The LC_{50} value for DF smoke came from arithmetic averages of values from the original Dalbey and Lock data[14] and a number of other values[19]; all these values had a range from 10300 to 38000 mg/m^3 with a ratio of the standard deviation to the mean (coefficient of variation) of 0.44. The LC_{50} value for RP and RP/BR was an average of two estimates of RP/BR (Refs. 2, 15), and the presence of butyl rubber (BR) was assumed to be insignificant. The LC_{50} value for WP and WP/FW was an average of four estimates, which had a range from 1300 to 4800 mg/m^3 (Refs. 2, 20) and no evident effect of the felt wedges (FW). The coefficient of variation was 0.61 for these values combined. The LC_{50} values for EA-5763 and EA-5769 found in an unclassified appendix[3] could not justifiably be separated so they were averaged. The LC_{50} value for HC smoke was estimated from the study attributed to Basman et al.,[4] but also compared with the data for mice,[21] considering that mice were usually more sensitive in similar studies by a factor of 2 to 3. In general, we felt that the relative ranges and coefficients of variation found for DF and WP were probably characteristic of all the smokes. The LC-50 values given in Table 5 could not be estimated with uncertainties less than about 50% because of normal variation.

TABLE 5. RELATIVE INHALATION TOXICITY OF SMOKES AND OBSCURANTS IN TERMS OF THE ONE-HOUR LC_{50} FOR RATS, RANKED IN ORDER OF INCREASING TOXICITY.

	LC_{50} (mg/m^3)	Relative toxicity
1. SGF-2 fog oil	60000	1
2. Diesel fuel smoke	26000	2
3. RP and RP/BR	4000	15
4. WP and WP/FW	2500	24
5. IR (EA 5763, EA 5769)	970	62
6. HC smoke	333	180

A preferred way to express the relative inhalation toxicity of smoke and obscurant devices is by means of the concentration quotient, (C.Q.), which is defined as the ratio of the environmental air concentration (C) to the particular LC_{50} value for inhalation toxicity to rats. The C.Q. values calculated for each device are given in Appendix B. The device categories given in Table 4 were re-ranked in terms of C.Q. and the values of C.Q. are given in Table 6. The S&O categories that had C.Q. values near unity and greater were the devices with potentially significant inhalation toxicity. Of these devices the S&O grenades were the most dangerous, especially the RP/BR and IR grenades. This is explained by the small volume of their clouds relative to fill weight. The artillery-produced smokes were the most toxic when in the form of HC and WP. The phosphorus smokes with wedges (RP/W and WP/FW) were far less toxic. HC smokepots were on the borderline of inhalation toxicity significance, while SGF-2 and DF were insignificant in terms of inhalation.

RANKING BY ORAL TOXICITY AND INGESTION QUOTIENT

The effect of S&O materials in the environment would depend on the pathway of toxicity. Direct ingestion would be unlikely for humans unless the material were deposited on crops. Animals that feed upon plants,

TABLE 6. AIR CONCENTRATION QUOTIENTS (C.Q.) FOR RELATIVE INHALATION TOXICITY OF S&O DEVICES, RANKED IN ORDER OF INCREASING TOXICITY.

	Device type	C.Q.[a]
1.	SGF-2 diffusing (fog oil generator, each hour)	0.0002
2.	DF diffusing (diesel fuel generator, each hou.	0.0003
3.	RP bursting (bomblet)	0.0003
4.	SGF-2 diffusing (smoke pot)	0.0004-0.002
5.	WP/FW bursting (howitzer and rockets)	0.002-0.01
6.	RP/W bursting (mortars and howitzers)	0.006-0.06
7.	HC diffusing (smoke pots)	0.04-0.25
8.	HC diffusing (grenade)	0.7
9.	WP bursting (mortars, guns, rockets, howitzers)	0.7-1.4
10.	HC diffusing (howitzers)	1.4-2.0
11.	RP/BR bursting (grenade)	3.4
12.	IR bursting (grenade)	>10

[a] C.Q. is the ratio of the environmental air concentration, C, to the one-hour lethal concentration (LC_{50}) for rats exposed by inhalation. Values near unity or greater indicate potentially significant toxicity problems.

however, could be acutely exposed if they consume the S&O material deposited on their forage. The relative toxicity of smoke types by ingestion was ranked in order of the oral LD_{50} values to rats, a concentration (mass of toxic material per body weight, mg/kg) found to be lethal to one-half the rats in an exposed population. Deposition was calculated on on page 15 for a smoke concentration of 1000 mg/m^3 using the deposition velocity, Eq. (17), and foliar retention was estimated using Chamberlains's NSC. Direct consumption by rats indicated a value estimated of accumulated smoke material of 6.5 g/kg (low range) if they ingested foliage exposed to smoke concentrations of 1000 mg/m^3 for one-hour. We ranked the smokes for acute environmental effects to animals by determining the foliage ingestion quotient, (F.I.Q.) which is defined as the ratio of the amount of contaminant ingested by rats

(6.5 g/kg) to the LD_{50} value for oral toxicity to rats. This screening method would indicate potential toxicity problems if the F.I.Q. values approach or exceed unity. The results show that the WP, RP, IR, and HC smokes are all significantly toxic when deposited on foliage consumed by animals; see Table 7. We determined the oral LD_{50} values in this case by examining the smoke product likely to be the agent present when foliar consumption occurred soon after the exposure.

The oral LD_{50} value for all phosphorus smokes was estimated as that for orthophosphoric acid.[22] When WP or RP are combusted, the reaction product P_2O_5 rapidly hydrolyzes.[11,23] In the environment the formation of cyclic metaphosphates is unlikely, and the linear polyphosphates usually found can be expected to hydrolyze very rapidly in the presence of normal amounts of moisture.[23] All the linear polyphosphates $H_{n+2}(P_n O_{3n+1})$ will hydrolyze to the orthophosphate ($n = 1$) form, H_3PO_4. For acute environmental effects (other than inhalation) we used the various properties of orthophosphoric acid in screening and ranking. The LD_{50} value for HC smokes was based on the estimate for zinc chloride,[22] which comprises about 80% of the combustion products. (The other significant combustion products are far less toxic than zinc chloride.) The LD_{50} value for SGF-2 was estimated as mid-range between that given for diesel fuel[24] and that for the polyethylene glycol (PEG-200; see Ref. 1)) with the justification that the aromatic hydrocarbon compounds of SGF-1 are similar to the middle distillates found to be toxic in diesel fuel and fuel oil, but the higher concentrations of aliphatic compounds are known to ameliorate the toxic effects. Subjective comparisons of SGF-2 with fuel oil and PEG-200 were found.[1,17,24,25] The LD_{50} value for EA-5763 and EA-5769 was estimated from the by-products we assumed to occur,[3] such as from copper and zinc in the brass.

RANKING BY AQUATIC TOXICITY QUOTIENT

The effect of a smoke and obscurant material on the aquatic environment would depend upon the solubility of the material in water, the toxicity to aquatic life, and upon the amount of material deposited into water bodies. We estimated that the deposition of S&O from a cloud with an air concentration of 1000 mg/m^3 passing over a water body 1 meter deep for one hour would result in S&O concentrations of about 3.6 mg/liter in the water. The aquatic

TABLE 7. FOLIAGE INGESTION QUOTIENT (F.I.Q.) FOR RELATIVE ORAL TOXICITY OF SMOKES AND OBSCURANTS TO RATS, RANKED IN ORDER OF INCREASING TOXICITY.

Smoke type	Rat LD_{50} (Oral) (mg/kg)	F.I.Q.[a]
1. SGF-2	21000	0.3
2. DF	14000	0.5
3. RP and RP/BR	1530	4.2
4. WP and WP/FW	1530	4.2
5. IR (EA-5763 and EA-5769)	800	8.1
6. HC smoke	350	19

[a] The F.I.Q. uses the value of 6500 mg/kg as an estimate of the amount of smoke products consumed by a rat when the foliage receives deposition from smoke at an air concentration of 1000 mg/m^3 for one-hour. The F.I.Q. is the ratio of 6500 mg/kg to the oral LD_{50} for rats. Values near or greater than unity indicate potential toxicity problems.

toxicity quotient, (A.T.Q.) was defined as the ratio of 3.6 mg/liter to the TLm_{96} for bioassay fishes. The TLm_{96} is the lethal concentration in water (mg/liter)for half of the fish after 96-hours of exposure. The A.T.Q. must be adjusted if the value 3.6 mg/liter exceeds the amount soluble in water; in that case A.T.Q. is the ratio of the amount soluble to the TLm_{96}. Aquatic toxicity from the major smoke types would be significant when the A.I.Q. approaches or exceeds unity. The HC smoke and IR smoke (EA-5763 and EA-5769) were found to be the most toxic to fishes while fog-oil and diesel fuel had borderline aquatic toxicity and WP and RP smoke types were of insignificant toxicity, see Table 8.

The TLm_{96} values for WP and RP were values for orthophosphoric acid,[22,26] and the values for HC were for zinc chloride.[21] The SGF-2 and DF were found to have about the same short-term solubility[17] and were given the same TLm_{96} estimates based upon toxicity of middle distillates present.[17] TLm_{96} values for IR were available in unclassified appendices.[3]

TABLE 8. AQUATIC TOXICITY QUOTIENT (A.T.Q.) FOR RELATIVE TOXICITY OF SMOKES AND OBSCURANTS TO BIOASSAY FISHES, RANKED IN ORDER OF INCREASING TOXICITY.

Smoke type	TLm_{96} (mg/liter)	A.T.Q.[a]
WP and WP/FW	100-1000	0.0036-0.036
RP and RP/BR	100-1000	0.0036-0.036
SGF-2	2-50	0.72-1.8
DF	2-50	0.72-1.8
IR (EA-5763 and EA-5769)	0.02-0.10	0.3-1.55[b]
HC	0.1-10	0.36-36

[a] A.T.Q. uses the value 3.6 mg/liter as an estimate of the amount of smoke products deposited in water 1-m deep from a one-hour exposure to an air concentration of 1000 mg/m^3. The A.T.Q. is the ratio of 3.6 mg/liter to the TLm_{96} for common bioassay fishes. Values near unity or greater are of significant aquatic toxicity.

[b] The low solubility of IR smoke requires that the A.T.Q. is a ratio of the amount soluble to the TLm_{96} in that case.

RANKING BY SHORT-TERM AND LONG-TERM MOBILITY IN THE ENVIRONMENT

The intermediate fate of smoke and obscurant materials in the environment was screened on the basis of the solubility in water of the initial chemical form when deposited on soil or water. Ranking on the basis of this factor would presume that initial mobility in soil and sediments should indicate potential problems. The initial solubility of WP or RP smokes was estimated as that of orthophosphoric acid,[27] the initial solubility of HC smoke as that of zinc chloride,[28] the initial solubility of fog oil and diesel fuel smoke as measured in a non-agitated, non-emulsified mixture,[17] and the initial solubility of IR smoke from brass constituents.[3] The results indicate that WP, RP, and HC inorganic forms that are highly soluble would be highly mobile, the dissolved organic components (presumably aromatics) in SGF-2 and DF would be slightly mobile, while IR (EA-5763 and EA-5769) would be

TABLE 9. MOBILITY OF FRESHLY DEPOSITED SMOKE AND OBSCURANT MATERIALS IN SOIL AND SEDIMENTS, RANKED ACCORDING TO INCREASING SOLUBILITY.

Smoke type	Solubility (mg/liter)	Relative rank
IR (EA-5763 and EA-5769)	0.03	1
SGF-2	14-52	$10^2 - 10^3$
DF	14-52	$10^2 - 10^3$
HC	4.3×10^6	10^8
WP and RP forms	5.5×10^6	10^8

very immobile; see Table 9.

The ultimate fate of S&O materials in the environment was estimated from the solubility in water of chemical forms thought to result long after deposition on soil or water. Again ranking by this procedure should indicate if transformed smoke components could become mobile. The HC smoke initially would consist of highly soluble zinc chloride and unreacted aluminum chloride plus insoluble forms such zinc and aluminum oxides. The chlorides hydrolyze rapidly[21] and form hydrochloric acid and zinc oxychlorides in the presence of normal moisture. In the soil and sediments these forms undergo ion-exchange readily. Studies attributed to Fuller[21] provided estimates for zinc ion as the soluble form in soils and zinc hydroxide as the soluble form in water. The chloride ions were disregarded because they enter a fairly large pool in natural soils and waters (e.g., sodium and potassium chlorides).

The IR materials (EA-5763 and EA-5769) and SGF-2 fog oil were given the same long term solubility as their estimated initial solubility. The solubility of DF was obtained from a measured solubility of DF after a few weeks in the environment.[17] The fate of orthophosphoric acid in low concentrations in soil and sediment is governed by the pH and type of clay mineral present.[12] The distribution of orthophosphate species as a function of pH is well known. Epitaxial adsorption on clay mineral surfaces and solid phase formation reactions show that apatites are formed as well as iron and aluminum phosphates. From Edzwald's adaptation of Stumm and Leckie[12] these

TABLE 10. LONG-TERM MOBILITY OF TRANSFORMED SMOKE AND OBSCURANT MATERIALS IN SOIL AND SEDIMENTS AT pH 7, RANKED ACCORDING TO INCREASING SOLUBILITY.

Smoke type	Solubility (mg/liter)	Relative rank
HC in soil	6.5×10^{-4}	1
IR (EA-5763 and EA-5769)	3×10^{-2}	50
SGF-2	14-52	10^4-10^5
HC in water	99	10^5
DF	360	6×10^5
WP and RP	1500	10^6

all have about the same solubility near pH 7. We used the solubility of $FePO_4$, which was slightly higher than the others, as an indicator species for the long-term fate of combusted WP and RP. The result was that of the S&O, the HC in soil and IR (EA-5763 and EA-5769) have insignificant long-term mobility compared to SGF-2, HC in water, DF, WP, and RP; see Table 10.

The S&O materials with the highest short-term solubility, (WP, RP, and HC) fresh after deposition, had decreased solubility by more than three orders of magnitude in the long term due to estimated transformation in the environment; compare Tables 9 and 10. This rapid transformation and demobilization, particularly of P and HC smokes essentially renders them less harmful to plant and animal life. More work is needed on the environmental fate of S&O materials and their potential toxicity in their transformed states. The screening showed that smoke combustion products and their dynamics in soil and water systems were relatively complicated and not well unified, although studied in some detail.

RANKING BY OVERALL ENVIRONMENTAL IMPORTANCE

We ranked the overall environmental importance of device categories by multiplying the minimum area of impact by the C.Q., F.I.Q, and A.T.Q. This empirical index is the product of area, relative inhalation toxicity, relative foliar ingestion toxicity, and relative aquatic toxicity with equal weighting. Numerically, it had units of area, and in the case of a given range of values the geometric mean was used. It was found that HC smoke pots are environmentally the worst problem by an order of magnitude above HC grenades and HC howitzers. These in turn are an order of magnitude worse than the IR grenades. All other devices are two orders of magnitude less important in overall environmental effects, see Table 11.

TABLE 11. OVERALL ENVIRONMENTAL IMPORTANCE FOR SMOKE AND OBSCURANT DEVICES, RANKED FROM LEAST TO MOST.

		Importance value[a]
1.	WP/FW (rockets and howitzers)	1.1
2.	SGF-2 (smoke pot)	2.5
3.	RP (bomblet)	2.8
4.	RP/W (mortars and howitzers)	3.3
5.	RP/BR (grenade)	8
6.	SGF-2 (generator)	13
7.	WP (mortars, guns, rockets, howitzers)	14
8.	DF (diesel fuel exhaust)	24
9.	IR (EA-5763 and EA-5769, grenade)	3×10^3
10.	HC (howitzers)	3×10^4
11.	HC (grenade)	5×10^4
12.	HC (smoke pots)	2×10^5

[a] Importance value is the product of area, C.Q., F.I.Q., and A.T.Q. with units in square meters.

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APPENDIX A

THE JUSTIFICATION OF MINIMUM IMPACT AREA, A', ESTIMATED FOR DIFFUSING MILITARY SMOKES

The concentration (C) for a ground-level continuous source in a uniform flow field of speed μ, is usually represented by a "Gaussian plume", for example see the "Handbook on Atmospheric Diffusion":[6]

$$C(x,y,z) = C(x,o,o)\exp -\frac{1}{2}(y/\sigma_y)^2 \exp -\frac{1}{2}(z/T_z)^2$$

where C(x,o,o) is the centerline concentration at groundlevel given by

$$C(x,o,o) = \frac{Q_c/t_c}{\pi\sigma_y\sigma_z u}$$

Here Q_c is the mass of material dispersed over a time period t_c, and σ_y, σ_z are the characteristic width and height of the plume. To a good approximation, σ_y and σ_z are linear functions of downwind distance, x, for burn times on the order of minutes. The downwind distance traveled is $x = ut_c$, and the ground area covered can be estimated as a triangle of length x and base $4\pi\sigma_y$. The value π is retained from integration of the concentration distribution in the vertical from ground level to infinity and in the crosswind, y-direction from minus infinity to plus infinity. If we solve for the concentration, C, at ground level ($z = 0$) and at $y = 5/3\ \sigma_y$ where the concentration is one-fourth of the centerline concentration we obtain

$$C = \frac{Q}{A'\sigma_z}$$

Thus the area A' defines 90% of the plume width ($y/\sigma_y = \pm 5/3$);

$$A' = 2\pi\sigma_y ut_c$$

and is the area containing greater than one-fourth the centerline concentration.

APPENDIX B.

TABLES OF CALCULATED ENVIRONMENTAL VARIABLES FOR SPECIFIC SMOKE AND OBSCURANT DEVICES[28]

TABLE B-1. WHITE PHOSPHORUS-TYPES.

Device	Munition	Type	A (m^2)	C (mg/m^3)
1. 4.2-inch mortar	M2	WP	516	3100
2. 4.2-inch mortar	M328AW	WP/PWP	541	3140
3. 60-mm mortar	M302	WP	166	1820
4. 81-mm mortar	M57	WP	366	2820
5. 81-mm mortar	M375	WP	228	2320
6. 90-mm gun	M313	WP	243	2490
7. 105-mm gun	M416	WP	455	2990
8. 120-mm gun	M357	WP	516	3100
9. 105-mm howitzer	M60	WP	354	2900
10. 155-mm howitzer	M110	WP	778	3470
11. 155-mm howitzer	XM825	WP/FW	12000	24
12. 5-inch rocket	MK4	WP/PWP	718	3390
13. 57-mm rocket	M308	WP	96	1900
14. 75-mm rocket	M311	WP	198	2350
15. 2.75-inch rocket	M259	WP/W	9500	6

TABLE B-2. RED PHOSPHORUS-TYPES

Device	Munition	Type	A (m^2)	C (mg/m^3)
1. grenade	L8A1	RP/BR	50	13600
2. 81-mm mortar	XM819	RP/W	940	139
3. 155-mm howitzer	XM803	RP	11300	26
4. bomblet (submunition)	CBU-88	RP	283000	1.3

TABLE B-3. INFRARED-TYPES

Device	Munition	Type	A (m^2)	C (mg/m^3)
1. grenade	XM-76	IR	50	10000

TABLE B-4. HEXACHLOROETHANE-TYPES

Device	Munition	Type	t_c (sec)	A (m^2)	C (mg/m^3)
1. smoke pot	M1	HC	390	9506	77
2. smoke pot	M5	HC	1020	65025	13
3. smoke pot	M4A2	HC	750	35156	29
4. grenade	M8	HC	126	992	218
5. 105-mm howitzer	105M84	HC	120	52	450
6. 155-mm howitzer	M116M1	HC	138	1190	664

TABLE B-5. FOG-OIL AND DIESEL-TYPES

Device	Class	Type	t_c (sec)	A (m^2)	C (mg/m^3)
1. generator, fog-oil	M3A3	SGF-2	3600	810000	5.9
2. generator, fog-oil	XM52	SGF-2	3600	810000	8.9
3. smoke pot, fog-oil	AN-M7	SGF-2	630	26200	66
4. exhaust, diesel	VEES	DF	3600	810000	8.3

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=General; IR/Experimental
+

S1066
Webster III, H.A., and D.S. Haas. 1978. "Test of Smoke/Flame Compositions in MK 99 Marine Smoke and Illumination Signal." Report NWSC/CR/RDTR-82, AD-B029040L. Naval Weapons Support Center, Crane, IN.

=Dyes & Colored Smokes
+Life Cycle-R & D; Munition Composition

S1067
U.S. Army Test & Evaluation Command. 1978. "Inventory Smoke Munition Test. Phase IIa. Vol. I." 607pp. Final Report DPG-FR-77-314-Vol-1, AD-B031191. Aberdeen Proving Ground, MD 21005. Attn: DRCPM-SMK-T.

=HC Smokes; Phosphorous Smokes
+Physical Properties-Aerosol; Munitions-Ground, Mortar, Artillery; Life Cycle-R & D, Use; Analytic Methods; Transport & Diffusion-Field Data, Models

S1068

Tarnove, T.L. 1980. "Studies of the Chemistry of the Formulation of Phosphorus-Derived Smokes and Their Implications for Phosphorus Smoke Munitions." Report ARCSL-TR-80049, AD-B053301L. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD.

=Phosphorous Smokes
+Chemical Properties; Reaction Products; Analytical Methods

S1069

Brown, B.J., G.E. Affleck, E.G. Cummings, R.L. Farrand, and W.C. Starke. 1981. "The Subchronic Effects of Repeated Exposure to White Phosphorus/Felt Screening Smokes in Rats." Report ARCSL-TR-80068, AD-B058048L. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD.

=Phosphorous Smokes
+Mammalian Toxicity-Chronic, Inhalation; Reaction Products

S1070

Chin, A., and L. Borer. 1981. "Studies of the Effluents from Burning Navy Green Smoke Devices." Report NWSC/CR/RDTR-156, AD-B061993L. Naval Weapons Support Center, Applied Sciences Dept, Crane, IN.

=Dyes & Colored Smokes
+Reaction Products; Analytic Methods

S1071

Cragin, J.H. 1982. "Chemical Obscurant Tests During Winter. Environmental Fate." Report CRREL-SR-82-19, AD-B068594L. Cold Regions Research and Engineering Lab, Hanover, NH.

=Phosphorous Smokes; IR/Experimental Smokes
+Reaction Products; Physical Properties-Aerosol; Transport & Diffusion-Field Data; Analytical Methods; Regulations; Human Health

S1072

Horsey, H.R., N. Hotter, and H.J. Bielecki. 1977. "Abstracts of Chemical Systems Laboratory Technical Publications 1 July - 30 September 1977." Report ARCSL-SP-77012, AD-C012418L. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD.

=General
+Chemical Properties; Physical Properties

S1073

Giglio, D.A., and J. Steedman. 1977. "Proceedings of the 1977 Smoke Symposium Held at Harry Diamond Laboratories on 25-26 January 1977." AD-C015516. Office of the Project Manager Smoke/Obscurants, Aberdeen Proving Ground, MD.

=General; Phosphorous Smokes; HC Smokes; Fog Oil Smokes; Diesel Fuel Smokes
+

S1074
Hess, G.M. 1979. "Aerosol Laser Passive Countermeasures." Report D180-24922-1 (Distributed only to U.S. Govt. Agencies), AD-C018650L. Boeing Aerospace Co., Seattle, WA.

=IR/Experimental Smokes
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S1075
Newell, R.S., H.L. Lamuth, C.V. Levere, E.E. Westbrook, and L.R. Lowe. 1981. "Requirements for Smoke Screens to Defeat Sensors in the Infrared Spectrum." (Distributed only to US Govt Agencies), AD-C026933L. Prepared in cooperation with Battelle Columbus Labs, OH. AAI Corp., Baltimore, MD. DAAK11-79-C-0123.

=IR/Experimental Smokes
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S1076
Holt, L.J. 1982. "The CBU-88/B Bomb Cluster Smoke Development Program." Report NWC-TP-6040, AD-C029375L. Naval Weapons Center, China Lake, CA.

=IR/Experimental Smokes; Phosphorous Smokes
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S1077
Barr, W.A. 1982. "Chemical Systems Laboratory Information Exchange Meetings, 30 September and 9 November, 1982." Report ARCSL-SP-83008, AD-C030723. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD.

=General
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S1078
Wenz, D.J., and R.S. Wentsel. 1983. "Programmatic Life Cycle Environmental Assessment for Smoke/Obscurants. Vol. No. 3 of 5. Infrared." Report ARCSL-EA-83005, AD-C033575. Chemical Research and Development Center, Aberdeen Proving Ground, MD.

=IR/Experimental Smokes; Phosphorous Smokes
+Chemical Properties; Transport & Diffusion-Models; Mammalian Toxicity-Acute, Chronic, Inhalation, LD50; Aquatic Toxicity; Munitions-Grenade, Ground, Tank, Mortar, Aerial; Life Cycle-R & D; Air Pollution; Regulations

S1079
Liss-Suter, D., R. Mason, and P.N. Craig. 1978. "A Literature Review - Problem Definition Study on Selected Toxic Chemicals. Vol. No. 1 of 8. Occupational Health and Safety Aspects of Diesel Fuel and White Smoke Generated from It." Final Report, AD-A056018. The Franklin Institute Research Laboratories, Science Information Services Department, Benjamin Franklin Parkway, Philadelphia, PA, 19103. DAMD-17-77-C-7020.

=Diesel Fuel Smokes
+Chemical Properties; Physical Properties; Human Health-Epidemiology; Mammalian Toxicity-Acute, LD50, Metabolism; Carcinogenicity; Analytical Methods; Reaction Products; Regulations

S1080
Wasti, K., K.J.R. Abaidoo, and J.E. Villaume. 1978. "A Literature Review - Problem Definition Study on Selected Toxic Chemicals. Vol. No. 2 of 8. Occupational Health and Safety Aspects of Phosphorus Smoke Compounds." Final Report, AD-A056019. The Franklin Institute Research Laboratories, Science Information Services Department, Benjamin Franklin Parkway, Philadelphia, PA, 19103. DAMD-17-77-C-7020.

=Phosphorous Smokes
+Munition Composition; Chemical Properties; Physical Properties; Human Health-Clinical, Epidemiology; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation, Metabolism; Carcinogenicity; Analytical Methods; Reaction Products; Regulations

S1081
Hill, H.G., J.E. Villaume, and K. Wasti. 1978. "A Literature Review - Problem Definition Study on Selected Toxic Chemicals. Vol. No. 5 of 8. Occupational Health and Safety and Environmental Aspects of Zinc Chloride." Final Report, AD-A056020. The Franklin Institute Research Laboratories, Science Information Services Department, Benjamin Franklin Parkway, Philadelphia, PA, 19103, DAMD-17-77-C-7020.

=HC Smokes; Zinc Chloride
+Chemical Properties; Physical Properties; Aquatic Toxicity; Mammalian Toxicity; Carcinogenicity; Phytotoxicity; Human Health; Food Chain-Uptake, Bioconcentration; Regulations; Reaction Products; Water Pollution; Soil Contamination; Transport & Diffusion-Models

S1082
Dacre, J.C., W.D. Burrows, A.F. Hegyeli, C.W.R. Wade, T.A. Miller, and D.R. Cogley. 1979. "Problem Definition Study on Potential Environmental Pollutants. V. Physical, Chemical, Toxicological, and Biological Properties of Seven Substances Used in Pyrotechnic Compositions." Technical Report 7704, AD-A090631. U.S. Army Medical Research and Development Command, ATTN: SGRU-UBG, Fort Detrick, Frederick, MD, 21701.

=HC Smokes; Dyes & Colored Smokes
+Chemical Properties; Physical Properties; Human Health-Epidemiology; Mammalian Toxicity-Acute, Chronic, LD50, Wildlife; Aquatic Toxicity; Phytotoxicity; Mutagenicity; Carcinogenicity; Analytical Methods; Regulations; Life Cycle-Manufacture, Use, Inventory

S1083
Crook, J.W., P. Hott, H.T. Weimer, R.L. Farrand, A.E. Cooper, J.H. Manthei, R. Nelson, and D.H. Heitcamp. 1981. "The Acute Toxicity of Polyethylene Glycol 200 in Laboratory Animals." Report ARCSL-TR-81058, AD-A106519. Chemical Systems Laboratory, ATTN: DRDAR-CLJ-R, Aberdeen Proving Ground, MD, 21010.

=PEG 200
+Chemical Properties; Physical Properties-Aerosol; Mammalian Toxicity-Acute, Inhalation, LD50, Metabolism; Mutagenicity; Analytical Methods; Life Cycle-R&D

S1084
Henry, M.C., C.D. Rowlett, and J.J. Barkley Jr. 1981. "Mammalian Toxicologic Evaluation of Hexacholoroethane Smoke Mixture and Red Phosphorus." AD-A109593.
Litton Bionetics Inc., 5516 Nicholson Lane, Kensington, MD 20795, DAMD17-78-C-8086.

=HC Smokes; Phosphorous Smokes
+Chemical Properties; Munition Composition; Reaction Products; Life Cycle-Manufacture; Analytical Methods; Mammalian Toxicity-Acute

S1085
Liss-Suter, D., J.E. Villaume, and P.N. Craig. 1984. "A Literature Review - Problem Definition Studies on Selected Toxic Chemicals. Vol. No. 4 of 8. Occupational Health and Safety Aspects of Diesel Fuel and Fog Oils SGF No. 1 and SGF No. 2 and Smoke Screens Generated from Them." Final Report, AD-A055903. The Franklin Institute Research Laboratories, Science Information Services Department, Benjamin Franklin Parkway, Philadelphia, PA, 19103. DAMD17-77-C-7020.

=Fog Oil Smokes
+Chemical Properties; Physical Properties-Aerosol; Human Health-Clinical, Epidemiology; Mammalian Toxicity-Acute, Chronic, LD50, Metabolism; Carcinogenicity; Mutagenicity; Munitions-Ground; Munition Composition; Analytical Methods; Regulations

S1086
Drummond, J.D. 1981. "Analyses of Smoke Week I for HC, WP, and Foreign WP." Report ERADCOM/ASL-CR-81-0008-1, AD-E800272. AD-A098590/3. New Mexico State Univ., Physical Science Lab., Las Cruces, NM.

=HC Smokes; Phosphorous Smokes
+Analytical Methods

S1087
McKenney Jr, R.L. 1971. "Development of Experimental Intermetallic-Forming Starter System for the M1 Smoke (HC) Canister. Final Report. May-Aug 1971." Report AFATL-TR-71-136, AD-892269/2. Air Force Armament Lab., Eglin AFB, FL.

=HC Smokes
+Munitions - Ground, Artillery; Physical Properties; Life Cycle - R & D; Munition Composition; Analytical Methods; Socioeconomics-Costs; Reaction Products

S1088
Hansen, F.V., R. Pena, and R.K. Umstead. 1980. "Deliberate Air Pollution: The Art of Smoke Screening." AD-A090399. Army Electronics Research and Development Command, Atmospheric Sciences Lab., White Sands Missile Range, NM.

=HC Smokes; Phosphorous Smokes; Fog Oil Smokes
+Transport & Diffusion-Models

S1089
Sullivan, J.D., and R.G. Reitz. 1980. "Fuel-Air Explosions in a Fog Oil Smoke Environment. Final Report." Report ARBRL-MR-02985, AD-E430393. AD-A083294/9. Army Armament Research and Development Command, Ballistics Research Lab., Aberdeen Proving Ground, MD.

=Fog Oil Smokes
+Transport & Diffusion-Models, Field Data

S1090
Marchetti, R.M. 1979. "A Transport and Diffusion Model for Smoke Munitions." Report AMSAA-TR-272, AD-A079489. Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, MD.

=Phosphorous Smokes; HC Smokes
+Munitions-Artillery; Transport & Diffusion-Models

S1091
Fry Jr., R.R. 1977. "Method for Preparing a Smoke Agent (Patent)." Report PAT-APPL-843 390, PATENT-4 151 233, AD-D006361/0. Department of the Army, Washington, DC.

=General
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S1092
Gremillion, A.F., and D.A. Lieblong. 1979. "Study and Evaluation of Several Smoke-Generating Materials for Use in Hazard-Free Cartridges for 81-mm Mortar Inert Training Ammunition. Final Report." AD-A070824. BEI Electronics Inc, Little Rock, AR.

=HC Smokes; Dyes & Colored Smokes
+Munitions-Mortar; Munition Composition; Reaction Products; Life Cycle-R&D

S1093
Pennsyle, R.O. 1979. "Methodology for Estimating Smoke/Obscurant Munition Expenditure Requirements. Technical Report. May-Dec 1978." Report ARCSL-TR-79022, AD-A069157. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD.

=General
+Munitions-Ground, Artillery; Transport & Diffusion-Models; Life Cycle-Inventory, Use

S1094
Kitchens, J.F., W.E. Harward III, D.M. Lauter, R.S. Wentsel, and R.S. Valentine. 1978. "Preliminary Problem Definition Study of 48 Munitions-Related Chemicals. Vol. III. Pyrotechnic Related Chemicals. Final Report. October 1977-April 1978." Report ARC-49-5730-03. AD-A066309. Atlantic Research Corp., Alexandria, VA.

=Phosphorous Smokes; Dyes & Colored Smokes; HC Smokes
+Chemical Properties; Physical Properties; Transport & Diffusion; Munitions-Grenade, Ground; Reaction Products; Aquatic Toxicity; Mammalian Toxicity; Life Cycle-Manufacture, Inventory, Use

S1095
McIntyre, F.L. 1975. "Explosive Classification Testing for Pyrotechnic Bulk Composition and End Items. Technical Report. 24 September 1973-June 74." Report EA-4D51, EM-CR-74054, AD-B004013/9. General Electric Co., Engineering and Science Services Lab, Bay Saint Louis, MS.

=General
+Analytic Methods; Life Cycle-T&S; Munitions-Artillery, Ground

S1096
Dolce, T.J., and D.F. Metz. 1977. "An Analysis of the Smoke Cloud Data from the August 1975 Jefferson Proving Ground Smoke Test. Technical Report." Report AMSAA-TR-201, AD-A045874/5. Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, MD.

=Phosphorous Smokes; HC Smokes
+Munitions-Artillery, Ground; Transport & Diffusion-Field Data, Models

S1097
Needels, C.J. 1977. "The Simulation of Tactical Smoke on the Modern Battlefield. Final Report." Master's thesis, AD-A043839/0. Army Command and General Staff Coll., Fort Leavenworth, KS.

=General
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S1098
Smith, M.D., and C.S. Ferrett Jr. 1977. "Advanced Technology for Pyrotechnic Mixtures and Munitions. Technical Report. September 1972-August 1976." Report ARCSL-TR-77043, EM-TR-77030, AD-A042790. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD.

=Dyes & Colored Smokes
+Munitions-Grenade; Life Cycle-Manufacture; Socioeconomics-Cost; Chemical Properties; Physical Properties

S1099
Shidlovsky, A.A. 1965. "Fundamentals of Pyrotechnics. Technical Memo." Report PA-TM-1615, AD-462474. Feltman Research Labs. Picatinny Arsenal, Dover, NJ.

=General
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S1100
Weeks, M.H. 1960. "The Toxicity of Combustion Products of Pyrotechnics. Technical Memo. 7 August - 26 October 1959." Report CWL-TM-26-12, AD-474403/3. Army Chemical Warfare Labs, Army Chemical Center, MD.

=Dyes & Colored Smokes; Phosphorous Smokes
+Reaction Products; Mammalian Toxicity-Acute, Inhalation; Munition Composition; Analytical Methods

S1101
Lewis, J.W. 1965. "Human Factors Evaluation of the E24 CS Munition. Technical Memo." Report CRDL-TM-2-34, AD-474350/6. Chemical Research and Development Labs, Edgewood Arsenal, MD.

=General
+Munitions - Grenade

S1102
McLain, W.H., and R.W. Evans. 1965. "A New Smoke Screening Chemical for Use in Aerial Smoke Tanks. Summary Progress Report No. 6 (Final)." Final Report DRI-2304 448-6512-F, AD-479680. University of Denver, Mechanics Division, Denver Research Institute, CO. DA 18-035-AMC-127(A).

=Phosphorous Smokes; Fog Oil Smokes; Experimental Smokes
+Munition Composition; Life Cycle - R&D; Munitions - Aerial; Physical Properties; Chemical Properties; Mammalian Toxicity

S1103
Gordon, M.G. 1975. "Smoke Seminar, 20 August 1974. Special Publication." Report ED-SP-75003, AD-A015987. Edgewood Arsenal, Aberdeen Proving Ground, MD.

=IR/Experimental Smokes
+Munitions-Aerial, Artillery; Life Cycle-R&D, Manufacture, Use, Demil; Physical Properties-Aerosol; Transport & Diffusion-Models; Analytical Methods

S1104
Gerber, M.N., and W.W. Reaves. 1973. "Plastic Bonded Smoke (Patent)." Report PAT-APPL-93 207, PATENT-3 726 225, AD-D001119/7. Department of the Army, Washington, DC.

=Phosphorous Smokes
+

S1105
Kohl, R.H. 1980. "Proceedings of the 1979 Chemical System Laboratory Scientific Conference on Obscuration and Aerosol Research. Contract Report." Report No.: ARCSL-CR-81023; AD-A113733/0. Kohl (Ronald H.) and Associates, Tullahoma, TN.

=General; Phosphorous Smokes; HC Smokes; Fog Oil; Diesel Fuel; IR/Experimental
+

S1106
Turner, R.E., P.G. Eitner, C.D. Leonard, and D.G.S. Snyder. 1980. "Battlefield Environment Obscuration Handbook. Vol. I. Final Report. December 1979 - December 1980." Report No.: SAI-80-009-AA-VOL-1 ; AD-A102822/4. Science Applications, Inc., Ann Arbor, MI.

=General; Phosphorous Smokes;HC Smokes; Diesel Fuel Smokes; Fog Oil Smokes; IR/Ex.
+Transport & Diffusion-Models, Field Data; Life Cycle-Use (Scenarios); Socioeconomics-Demography; Physical Properties; Munitions-Grenade, Mortar, Tank, Ground; Munition Composition; Reaction Products

S1107
Zirkind, R. 1979. "A Battlefield Obscuration Model (Smoke & Dust). Final Report. July 1977 - October 1979." AD-A080459/1. General Research Corp., McLean, VA. Operations Analysis Group.

=General
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S1108
U.S. Department of the Army. 1983. "Obscuring smoke munition." <u>Army Research, Development, & Acquisition</u>, August, 1983, Vol. 24, Issue 4, p.26

=General
+Life Cycle-Use

S1109
Bulger, J.P. 1982. "Obscurants: countermeasures to modern weapons." <u>Military Review.</u> 62(5):45-53.

=General
+Life Cycle-Manufacture,Use; Munitions-Grenade,Mortar,Aerial,Ground; Transport & Diffusion-Field Data,Models

S1110
U.S. Department of the Army. 1982. "Smoke and Obscurants Program. "Keep on Smokin"." <u>Army Research, Development, & Acquisition.</u> 23(3):1-3.

=General
+Life Cycle-Use

S1111
Smith, M.D., and F.M. Stewart. 1982. "Environmentally acceptable smoke munitions." <u>Proc. Int. Pyrotech. Semin.</u> 8:623-35. U.S. Army Armament Research and Development Command, Chemical Systems Laboratory, Aberdeen Proving Ground, MD, 21010.

=Phosphorous Smokes; Dyes & Colored Smokes
+Munitions-Grenade, Ground; Munition Composition; Life Cycle-R&D, Manufacture, Inventory; Socioeconomics-Cost

S1112
Burrows, D. et al. 1973. "Mammalian Toxicology and Toxicity to Aquatic Organisms of White Phosphorus and "Phossy Water", a Waterborne Munitions Manufacturing Waste Pollutant - A Literature Evaluation." Prepared for: U.S. Army Medical Research and Development Command. Associated Water and Air Resources Engineers Inc.

=Phosphorous Smokes
+Aquatic Toxicity; Mammalian Toxicity; Life Cycle-Demil

S1113
Manthei, J.H., F.K. Lee, M. Donnelly, and J.T. Weimer. 1980. "Preliminary Toxicity Screening Studies of 11 Smoke Candidate Compounds." Report ARCSL-TR-79056, AD-C021764L.

=IR/Experimental Smokes
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S1114
Cooper, A.E., and E.J. Owens. . "A Review of the Toxicology of Screening Smokes." Private document provided by U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, MD.

=General
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S1115
Dalbey, W., S. Lock, B. Holmberg, J. Moneyhun, and M. Guerin. 1981. "Acute exposures of rats to an inhaled aerosol of diesel fuel." Proc. of the Smoke/Obscurants Symp. V, Harry Diamond Laboratories, Adelphi, MD. 2:759-771.

=Diesel Fuel Smokes
+Mammalian Toxicity-Acute, Metabolism, Chronic; Physical Properties-Aerosol; Analytical Methods

S1116
Hilado, C.J., and M.T. Lopez. 1977. "Relative toxicity of pyrolysis products of some elastomers." J. Combustion Toxicol 4(1):61-68.

=Phosphorous Smokes
+Reaction Products; Mammalian Toxicity-Acute, Inhalation; Food Chain-Uptake

S1117
Jarvis, A. 1970. "The combustion reactions of a pyrotechnic white smoke composition." Combust. Flame 14:313-320.

=HC Smokes; Zinc Chloride
+Munition Composition; Reaction Products; Analytical Methods

S1118
Burrows, D. et al. 1975. "Toxicity to Aquatic Organisms and Chemistry of Nine Selected Waterborne Pollutants from Munitions Manufacture - A Literature Evaluation." Technical Report TR-7503, AD-A010660. U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, MD.

=Phosphorous Smokes
+Chemical Properties; Aquatic Toxicity; Water Pollution; Reaction Products

S1119
Rosenblatt, D.H., and W.R. Hartley. 1984. "The Preliminary Pollutant Limit Value Concept." Private document provided by U.S. Army Medical Bioengineering Research and Development Laboratory, Health Effects Research Division, Fort Detrick, MD.

=General
+Human Health-NOEL, LD50; Regulations; Socioeconomics-Demography; Water Pollution; Soil Contamination

S1120
Rosenblatt, D.H., J.C. Dacre, and D.R. Cogley. 1982. "An environmental fate model leading to preliminary pollutant limit value for human health effects." In R.A. Conway, ed. Environmental Risk Analysis for Chemicals. pp. 474-505. Van Nostrand Reinhold, New York, NY.

=General
+Transfer & Diffusion-Models; Water Pollution; Soil Contamination; Food Chain-Transfer Coefficient; Regulations

S1121
Rosenblatt, D.H. 1981. "Environmental Risk Assessment for Four Munitions-Related Contaminants at Savanna Army Depot Activity." Technical Report 8110, AD-A116650. U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, MD.

=General
+Aquatic Toxicity; Soil Contamination; Regulations

S1122
Rosenblatt, D.H., and M.J. Small. 1981. "Preliminary Pollutant Limit Values for Alabama Army Ammunition Plant." Technical Report 8105, AD-A104203. U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, MD.

=General; Dyes & Colored Smokes
+Soil Contamination; Food Chain-Uptake, Transfer Coefficient; Socioeconomics-Demography; Regulations

S1123
Rosenblatt, D.H., and R.J. Kainz. 1982. "Options and Recommendations for a Polybromobiphenyl Control Strategy at the Gratiot County, Michigan Landfill." Technical Report 8204, AD-A121243. U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, MD.

=General
+Soil Contamination; Water Pollution; Human Health; Socioeconomics-Demography; Regulations

S1124
American Conference of Governmental and Industrial Hygienists (ACGIH). 1976. "TLV's Threshold Limit Values for Chemical Substances in Workroom Air." In N.I. Sax. Dangerous Properties of Industrial Materials, 4th Edition. Van Nostrand Reinhold, New York, NY.

=General
+Chemical Properties; Physical Properties; Human Health; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation; Carcinogenicity; Mutagenicity; Regulations

S1125
Christensen, H.E., T.T. Luginbyhl, and B.S. Carroll, eds. 1980. Registry of Toxic Effects of Chemical Substances. U.S. Dept of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

=General
+Chemical Properties; Physical Properties; Human Health; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation; Carcinogenicity; Mutagenicity; Regulations

S1126
Sax, N.I. 1975. Dangerous Properties of Industrial Materials, 4th Edition. Van Nostrand Reinhold Co., New York, NY.

=General
+Chemical Properties; Physical Properties; Human Health; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation; Carcinogenicity; Mutagenicity; Regulations

S1127
Leong, K.J., and H.N. MacFarland. 1983. "Hazards from thermodecomposition of epoxy resins." Arch. Environ. Health. 7:675-681.

=Phosphorous Smokes
+Reaction Products; Human Health; Mammalian Toxicity-Inhalation, LD50, Metabolism; Analytical Methods

S1128
Brown, H.S., C.A. Rowan, and D.R. Bishop. 1984. "Development of an air toxics program in Massachusetts." Proc. of the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA June 24-29, 1984. 84(7.3):2-28.

=General
+Regulations; Air Pollution; Carcinogenicity; Mutagenicity; Teratogenicity; Human Health; Analytical Methods; LD50

S1129
Patrick, D.R. 1984. "EPA's process of assessing and managing risks posed by exposure to toxic air pollutants." Proc. of the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA June 24-29, 1984. 84(103.2):2-7.

=General
+Regulations; Carcinogenicity; Air Pollution; Socioeconomics-Demography

S1130
Fossa, A.K., M.M. Riano, P.J. Lavin, and D.R. Vollmre. 1984. "New York State techniques and experience in regulation toxic air contaminants." Proc. of the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA June 24-29, 1984. 84(6.2):2-16.

=General
+Regulations; Air Pollution; Carcinogenicity; Human Health-Inhalation

S1131
Ohmstede, W.D., and E.B. Stenmark. 1979. "A model for characterizing transport and diffusion of air pollution in the battlefield environment." AD-A128458. Proc. of the Joint Conference on Applications of Air Pollution Meteorology (2nd), 24- 29 Mar 80, New Orleans, LA. American Meteorological Society, Boston, MA. pp. 416-423.

=General
+Transport & Diffusion-Models

S1132
Gilliam, C.W., G.S. Bradley, and C.A. Lipscomb Jr. 1973. "Smoke Design Criteria." Report RDTR-238, AD-761615. Naval Ammunition Depot, Research and Development Department, Crane, IN 47522.

=Dyes & Colored Smokes
+Transport & Diffusion-Models

S1133
Pennsyle, R.O., and R. Winkler. 1982. "Computer Program For Smoke/Obscurant Hazard Prediction (HA2RD2)." U.S. Army Armament Research and Development Command, Chemical Systems Lab, Aberdeen Proving Ground, MD. DAAK11-80-C-0091.

=General
+Munitions; Transport & Diffusion-Models; Munition Composition

S1134
Petrovic, K., and D. Vitorovic. 1976. "Recognition and qualitative characterization of commercial petroleum fuels and synthetic fuels by a gas chromatographic fingerprinting technique." J. Chromatogr. 119:413-422.

=Fuel Oil Smokes; Diesel Fuel Smokes
+Analytical Methods; Physical Properties; Chemical Properties

S1135
Fitzgerald, M.E., V.A. Cirillo, and F.J. Galbraith. 1962. "Mass spectrometric method for analysis of petroleum distillates in the furnace oil-kerosine boiling range." Analy. Chem. 34(10)1276-1280.

=Fuel Oil Smokes; Diesel Fuel Smokes
+Analytical Methods

S1136
Albro, P.E., and L. Fishbein. 1970. "Absorption of aliphatic hydrocarbons by rats." Biochim. Biophys. Acta. 219:437-446.

=Fuel Oil Smokes; Diesel Fuel Smokes
+Mammalian Toxicity - Metabolism; Analytical Methods

S1137
Wagner, W.O., O.J. Dobrogorski, and H.E. Stokinger. 1961. "Antagonistic action of oil mists on air pollutants." Arch. Environ. Health. 2(5):523-534.

=Fuel Oil Smokes; Diesel Fuel Smokes
+Mammalian Toxicity - Inhalation, Acute, Chronic, LC50; Human Health; Carcinogenicity; Physical Properties - Aerosol; Analytical Methods; Chemical Properties

S1138
Brahmachari, H.D. 1958. "Toxicity of white oil." Current Sci. 27(11):440-441.

=Fog Oil Smokes
+Mammalian Toxicity

S1139
Ghoshal, A.K., E.A. Porta, and W.S. Hartroft. 1971. "Isotopic studies on the absorption and tissue distribution of white phosphorus in rats." Exp. Mol. Pathol. 14(2):212-219.

=Phosphorous Smokes
+Mammalian Toxicity - Metabolism, Acute

S1140
Jongen, W.M.F., G.M. Alink, and J.H. Koeman. 1978. "Mutagenic effect of dichloromethane on Salmonella typhimurium." Mutat. Res. 56:245-248.

=Phosphorous Smokes; (Methylene Chloride)
+Mutagenicity

S1141
Pani, P., E. Gravela, and C. Mazzarino. 1972. "On the mechanism of fatty liver in white phosphorus poisoned rats." Exptl. Mol. Pathol. 16:201-209.

=Phosphorous Smokes
+Mammalian Toxicity - Metabolism; Analytical Methods

S1142
Lushbaugh, C.C., J.W. Green, and C.E. Redemann. 1950. "Effects of prolonged inhalation of oil fogs on experimental animals." Arch. Ind. Hyg. Occup. Med. 1:237-247.

=Fog Oil Smokes
+Mammalian Toxicity - Inhalation, Chronic, Metabolism; Human Health; Analytical Methods; Carcinogenicity

S1143
Shoshkes, M., W.G. Banfield Jr., S.J. Rosenbaum, and A.J. Fisk. 1950. "Distribution, effect and fate of oil aerosol particles retained in the lungs of mice. " Arch. Ind. Hyg. Occup. Med. 1:20-35.

=General; Fog Oil Smokes; Diesel Fuel Smokes
+Mammalian Toxicity - Chronic, Acute, Inhalation, Metabolism; Human Health

S1144
Edzwald, J.P. 1977. "Phosphorus in aquatic systems: The role of the sediments." In I.H. Suffet, ed. Fate of Pollutants in the Air and Water Environments, Part 1. pp. 183-214. John Wiley & Sons, New York, NY.

=Phosphorous Smokes
+Aquatic Toxicity; Water Pollution; Soil Contamination; Chemical Properties; Physical Properties; Reaction Products; Transport & Diffusion - Models

S1145
Fitzgerald, J.W. 1975. "Approximation formulas for the equilibrium size of an aerosol particle as a function of its dry size and composition and the ambient relative humidity." J. Appl. Meteorol. 14:1044-1049.

=General
+Physical Properties - Aerosol; Models

S1146
Turner, D., H.G. Baxter, G.M. Davies, A.R. Eyres, G.L. Lees, J. Mitchell, J.T. Sanderson, J. Steel, and J. P. Moore. 1975. "Methods for the determination of the atmospheric concentration of oil mist. " Ann. Occup. Hyg. 18(4):293-297.

=Fog Oil Smokes; Diesel Fuel Smokes
+Analytical Methods

S1147
Patterson, E.M., and D.A. Gillette. 1977. "Commonalities in measured size distributions for aerosols having a soil-derived component." J. Geophys. Res. 82:2074-2082.

=General
+Analytical Methods; Physical Properties - Aerosol; Transport & Diffusion - Field Data, Models

S1148
Giddings, J.C., G. Karaiskakis, K.D. Caldwell, and M.N. Myers. 1983. "Colloid characterization by sedimentation field-flow fractionation. I. Monodisperse populations." J. Colloid and Interface Sci. 92(1):66-88.

=General; IR/Experimental Smokes; Colloids
+Analytical Methods; Physical Properties - Aerosol; Transport & Diffusion - Field Data, Models

S1149
Yang F-S, K.D. Caldwell, and J.C. Giddings. 1983. "Colloid characterization by sedimentation field-flow fractionation. II. Particle-size distribution." J. Colloid and Interface Sci. 92(1):81-91.

=General; IR/Experimental; Colloids
+Analytical Methods; Physical Properties - Aerosol; Transport & Diffusion - Field Data, Models

S1150
Buchanan, D.J., M.V. Sigal Jr., C.S. Robinson, K. Pope, J.E. Ferguson, and J.B. Thomison. 1954. "Studies of phosphorus intoxication. I. Changes in blood, urine, and tissues of dogs poisoned with phosphorus." Arch. Ind. Hyg. Occup. Med. 1(9):1-8.

=Phosphorous Smokes
+Human Health; Mammalian Toxicity - Metabolism, Chronic; Analytical Methods

S1151
Lindauer, G.C., and A.W. Castleman Jr. 1971. "Initial size distributions of aerosols." Nucl. Sci. and Eng. 43:212-217.

=General
+Physical Properties-Aerosol; Transportation & Diffusion-Models

S1152
Barker, E.A., E.A. Smuckler, and E.P. Benditt. 1963. "Effects of thioacetamide and yellow phosphorus poisoning on protein synthesis in vivo." Lab. Invest., 12:955-960.

=Phosphorous Smokes
+Mammalian Toxicity

S1153
Diaz-Rivera, R.S., P.H. Collazo, E.R. Pons, and M.V. Torregrosa. 1950. "Acute phosphorus poisoning in man. A study of 56 cases." Medicine. 29:269-298.

=Phosphorous Smokes
+Human Health-Clinical

S1154
Talley, R.C., J.W. Linhart, A.J. Trevino, L. Moore, and A.M. Beller. 1972. "Acute elemental phosphorus poisoning in man: Cardiovascular toxicity." Amer. Heart J., 84:139-140.

=Phosphorous Smokes
+Human Health-Clinical; Mammalian Toxicity

S1155
Fleming, R.B. L., J.W. Miller, and V.R. Swayne Jr. 1942. "Some recent observations on phosphorus toxicology." J. Ind. Hyg. Toxicol. 24:154-158.

=Phosphorous Smokes
+Mammalian Toxicity-Acute, Chronic, Metabolism

S1156
Ryczak, R.S., and R.D. Miller. 1979. "A Review of Phosphorus Removal Technology." Technical Report 7706, AD A040802. U.S. Army Medical Bioengineering Research & Development Laboratory, Fort Detrick, MD 21701.

=Phosphorous Smokes
+Water Pollution; Food Chain-Uptake; Chemical Properties

S1157
Chan, T.L., and M. Lippmann. 1980. "Experimental measurements and empirical modeling of the regional deposition of inhaled particles in humans." Am. Ind. Hyg. Assoc. 41:399-409.

=General
+Human Health-Clinical; Mammalian Toxicity-Inhalation

S1158
Heimann, H. 1946. "Chronic phosphorus poisoning." J. Ind. Hyg. Toxiocl. 24(4):142-150.

=Phosphorous Smokes
+Human Health-Clinical, Epidemiology; Mammalian Toxicity-Chronic, Metabolism; Air Pollution

S1159
Cogley, D.R., L.E. Craker, C.D. Torgeson, and D.L. Sirois. 1979. "Biological Testing of Rocky Mountain Arsenal for Phytotoxic Substances. Final Report." AD A076565. Walden Division of Abcor, Inc., Wilmington, MA

=General
+Phytotoxicity; Soil Contamination

S1160
Craker, L.D., and J.C. Dacre. 1975. "Munitions-Related Substances of Potential Concern as Airborne Pollutants: A Phytotoxicological Evaluation." Final Technical Report 7511, AD A052168. U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, MD.

=General
+Phytotoxicity; Air Pollution; Analytic Methods

S1161
Howley, G.G. 1983. The Condensed Chemical Dictionary, 10th ed. Van Nostrand Reinhold Co., New York, NY.

=General
+Chemical Properties; Physical Properties; Mammalian Toxicity

S1162
Verschuren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY.

=General
+Chemical Properties; Physical Properties; Mammalian Toxicity; Water Pollution; Air Pollution; Carcinogenicity; Mutagenicity; Teratogenicity; Phytotoxicity; Food Chain-Bioconcentration, Uptake

S1163
Fowler, B.W., and T.B. Owens. 1979. "A Parametric Model for the Effect of White Phosphorus Smoke on Target Detection. I. Model Development." Technical Report 0-82-2, AD-A083787. U.S. Army Missile Command, Redstone Arsenal, AL.

=Phosphorous Smokes
+Transport & Diffusion-Models

S1164
Evans, E.H. 1945. "Casualties following exposure to zinc chloride smoke." <u>The Lancet.</u> 2:368-370.

=HC Smokes; Zinc Chloride
+Human Health-Epidemiology, Clinical

S1165
Pinnick, R.G., and S.G. Jennings. 1980. "Relationship Between Radiative Properties and Mass Content of Phosphoric Acid, HC, Petroleum Oil, Sulfuric Acid Military Smokes." Technical Report ASL-TR-0052, AD-A084941. U.S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

=General; Phosphorous Smokes; HC Smokes; Diesel Fuel Smokes; Fog Oil Smokes
+Physical Properties-Aerosol; Transport & Diffusion-Models

S1166
Spanggord, R.J., R.T. Podoll, R.T. Rewick, T.S. Chou, R.B. Wilson, J. Backovsky, and D.L. Roberts. 1983. "Environmental Fate of WP/F and RP/BR Military Screening Smokes. Phase I. Literature Review. Final Report (DRAFT)." Phase I. Final Report. SRI international, Menlo Park, CA. DAMD17-83-C-2320.

=Phosphorous Smokes
+Reaction Products; Water Pollution; Air Pollution; Soil Contamination; Food Chain; Physical Properties; Chemical Properties

S1167
Rubel, G.O. 1978. "Predicting the Droplet Size and Yield Factors of a Phosphorus Smoke as a Function of Droplet Composition and Ambient Relative Humidiyy under Tactical Conditions." Report ARCSL-TR-78057, AD-A064076. Chemical Systems Laboratory, Aberdeen Proving Ground, MD.

=Phosphorous Smokes
+Physical Properties-Aerosol; Transport & Diffusion-Models; Chemical Properties

S1168
Sullivan Jr., J.H., H.D. Putnam, M. A. Keirn, B.C. Pruitt, Jr. and J.C. Nichols. 04/7. "A Summary and Evaluation of Aquatic Environmental Data in Relation to Establishing Water Quality Criteria for Munition-Unique Compounds. Part 3. White Phosphorus." Final Report, AD-A083625. Water and Air Research Inc., P.O. Box 1121, Gainesville, FL, 32601. DAMD-17-77-C-7027.

=Phosphorous Smokes
+Water Pollution; Chemical Properties; Analytic Methods; Food Chain; Aquatic Toxicity

S1169
Lai, M. and D. Rosenblatt. 1977. "Identification of Transformation Products of White Phosphorus in Water." Report NSWC/WOL/TR-76-103, AD-A041068. U.S. Army Medical Research and Development Command, Fort Detrick, MD. DAMD17-77-C-7027.

=Phosphorous Smokes
+Reaction Products; Chemical Properties; Analytic Methods; Water Pollution

S1170
Windholz, M., S. Budavari, R.F. Blumetti, and E.S. Otterbein, eds. 1983. The Merck Index, 10th Edition. Merck & Co. Inc., Rahway, NJ.

=General
+Chemical Properties; Physical Properties; Mammalian Toxicity; Carcinogenicity; Aquatic Toxicity

S1171
Lee, Cheng-Chun; J.V. Dilley, J. R. Hodgson, D.O. Helton, W.J. Wiegand, D.C. Roberts, B.C. Anderson, L.M. Halfpap, and L.D. Kurtz. 1975. "Mammalian Toxicity of Munition Compounds. Phase I. Acute Oral Toxicity, Primary Skin and Eye Irritation, Dermal Sensitization, and Disposition and Metabolism." Formal Report 1, Project MRI 3900-B, AD-B011150. Midwest Research Institute, 425 Volker Blvd., Kansas City, MO, 64110. DAMD-17-74-C-4073.

=Phosphorous Smokes
+Analytic Methods; Chemical Properties; Physical Properties; Mammalian Toxicity

S1172
National Institutes of Health; Environmental Protection Agency. 1984. "Chemical Information System. On-Line Search." NIH-EPA/Chemical Information System, CIS, Inc.--Fein Marquait Associates, 7215 York Road, Baltimore, Maryland 21209.

=General
+Chemical Properties; Physical Properties; Mammalian Toxicity; Aquatic Toxicity; Phytotoxicity; Food Chain-Bioconcentration; Carcinogenicity; Water Pollution; Soil Contamination

S1173
Elkins, R.E., and R.H. Kohl - Editors. 1982. "Proceedings of the Smoke Obscurants Symposium VI, Held at HDL, 27-29 April, 1982. Vols. I, II (Unclassified Sections). Sponsored by PM Smoke/Obscurants." Technical Report DRCPM-SMK-T-001-82. Proc. of the Smoke/Obscurants Symp. VI, Harry Diamond Laboratories, Adelphi, MD. April 27-29, 1982. Unclassified sections.

=General
+Analytic Methods; Life Cycle-R & D; Transport & Diffusion-Models

S1174
Kennedy, B.W. 1981. "Battlefield Induced Contamination Test. Project Summary." Internal Report. U.S. Army Electronics Research and Development Command, Atmospheric Sciences Laboratory, White Sands Missile Range, NM 88002.

=General; HC Smokes; Phosphorous Smokes
+Analytic Methods; Transport & Diffusion-Models

S1175
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=General; Diesel Fuel Smokes; Fog Oil Smokes
+Air Pollution; Regulations; Human Health-Epidemiology; Phytotoxicity; Mammalian Toxicity

S1176
Daley, P.S. 1984. "Military marches toward new horizons in pollution control." Pollut. Eng. February 1984:31-42.

=General
+Air Pollution; Water Pollution; Regulations; Socioeconomic-Costs

S1177
Holst, G.C. 1984. "NATO smoke trials in France and Norway." Army Res., Dev. and Acquisition Magazine. September-October 1983:24-25.

=General
+Transport & Diffusion-Field Data; Analytic Methods

S1178
Blackman, G.R. 1983. "Cloud Geometry Analysis of the Smoke Week VA Obscuration Trials." Final Report ASL-DR-83-0009. U.S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM 88002.

=General
+Analytic Methods; Transport & Diffusion-Field Data

S1179
Whitacre, C.G., P.E. Robinson, W.L. Kneas, and A.L. Freeman. 1977. "Computer Program For Chemical Hazard Prediction." Report ARCSL-TR-77049. Chemical Systems Laboratory, Attn: DRDAR-CLY-A, Aberdeen Proving Ground, MD 21010.

=General
+Transport & Diffusion-Models

S1180
Gomez, R., and M.H. Van Atta. 1984. "Corps of Engineers airland battlefield environment thrust." Army Res., Dev. and Acquisition Magazine. May-June 1984:17-19.

=General
+Life Cycle-R & D, Use

S1181
Wentsel, R. 1983. "Environmental Effect Studies on EA5763." Chemical Research and Development Center, ATTN: DRSMC-CLT-I (A)/Dr. Wentsel, Aberdeen Proving Ground, Maryland 21010.

=Experimental Smokes
+Soil Contamination; Water Pollution; Phytotoxicity; Aquatic Toxicity; Reaction Products; Analytic Methods

S1182
Shinn, J.H. 1979. "Problems in the assessment of air pollution effects on vegetation." In J.R. Pfafflin and E.N. Ziegler, eds. Advances in Environmental Science and Engineering, Vol. 2. pp. 88-105. Gordon and Breach Publishers, New York, NY.

=General
+Air Pollution; Phytotoxicity; Regulations

S1183
Rosenblatt, D.H. 1984. "Guest editorial: The name of the game." Enivron. Sci. and Technol. 18(2):39A.

=General
+Air Pollution; Water Pollution; Soil Contamination; Socioeconomics-Cost; Regulations

S1184
U.S. Army Atmospheric Sciences Laboratory and The U.S. Army Project Manager-Smoke Obscurants. 1983. "Atmospheric aerosol and optics data library." Atmos. Aerosol and Optics Data Library Bulletin. 1(2):9-16.

=General
+Transport & Diffusion-Field Data; Physical Properties-Aerosol

S1185
Ratney, R.S., H. Wegman, and H.B. Elkins. 1974. "In vivo conversion of methylene ch[illegible]de to carbon monoxide." Arch. Environ. Health. 18:223-26.

=Phosphorous Smokes
+Human Health-Epidemiology; Regulations; Analytic Methods

S1186
D'Amico, W.P., W.H Clay, and A. Mark. 1979. "Diagnostic Tests for Wick-Type Payloads and High Viscosity Liquids. Final Report." Final Report ARBRL-MR-02913, AD-E430270, AD-A072812/1. U.S. Army Armament Research and Development Command, Ballistics Research Lab, Aberdeen Proving Ground, MD.

=Phosphorous Smokes
+Munitions-Artillery

S1187
Sax, N.I. 1984. Dangerous Properties of Industrial Materials, 6th Edition. Van Nostrand Reinhold Co. New York, NY.

=General
+Chemical Properties; Physical Properties; Human Health; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation; Carcinogenicity; Mutagenicity; Regulations

S1188
Windholz, M., S. Budavari, L.Y. Stroumtsos, and M.N. Fertig, eds. 1976. The Merck Index, 9th Edition. Merck & Co. Inc., Rahway, NJ.

=General
+Chemical Properties; Physical Properties; Mammalian Toxicity; Aquatic Toxicity; Carcinogenicity

S1189
Hanna, S.R., G.A. Briggs, and R.P. Hosker, Jr. 1982. "Handbook on Atmospheric Diffusion." Technical Information Center, U.S. Department of Energy. Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration.

=General
+Transport & Diffusion-Models

S1190
Conway, P.E., ed. 1982. Environmental Risk Analysis for Chemicals. Van Nostrand Reinhold Co., New York, NY.

=General
+Chemical Properties; Physical Properties; Reaction Products; Air Pollution; Water Pollution; Soil Contamination; Carcinogenicity

S1191
Brakhnova, I.T. 1975. Environmental Hazards of Metals. Consultants Bureau, New York, NY.

=General
+Chemical Properties; Physical Properties-Aerosols; Human Health-Epidemiology; Mammalian Toxicity

S1192
Newell, R.S., and J.T. Brown. 1976. "Analysis of Large-Area Screening Systems. Vol. 1. Executive Summary." Executive Summary, AD-B07342. Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH, 43201. DAAA15-77-C-0030.

=General; Fog Oil Smokes; IR/Experimental Smokes
+Analytic Methods; Life Cycle-R & D, Use; Transport & Diffusion-Models; Socioeconomics-Cost

S1193
Lyman, W.J., W.F. [illegible], and D.H. Rosenblatt. 1982. Handbook of Chemical Property Estimat[illegible]ethods, Environmental Behavior of Organic Compounds. McGraw-Hill Book Company, New York, NY.

=General
+Chemical Properties; Physical Properties; Food Chain-Bioconcentration, Uptake, Transfer Coefficient; Mammalian Toxicity; Aquatic Toxicity

S1194
Johnson, F.A., and R.B. Stonehill. 1961. "Chemical pneumonitis from inhalation of zinc chloride." Diseases of the Chest. 40:619-624.

=HC Smokes
+Human Health-Clinical

S1195
Kennedy, G.L., and H.J. Trochimowicz. 1982. "Inhalation toxicology." In A. Wallace Hayes, ed. Principles and Methods of Toxicology. pp. 185-207. Raven Press, New York, NY.

=General
+Air Pollution; Mammalian Toxicity-Inhalation; Analytic Methods

S1196
Sax, N.I. 1979. Dangerous Properties of Industrial Materials, 5th Edition. Van Nostrand Reinhold Co., New York, NY.

=General
+Chemical Properties; Physical Properties; Human Health; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation; Carcinogenicity; Mutagenicity; Regulations

S1197
Laskowski, D.A., C.A.I. Goring, P.H. McCall, and R.L. Swann. 1982. "Terrestrial environment." In R.A. Conway, ed. Environmental Risk Analysis for Chemicals. Chapter 6. Van Nostrand Reinhold Co., New York, NY.

=General
+Transfer & Diffusion-Models; Water Pollution; Soil Contamination; Food Chain-Transfer Coefficient; Regulations

S1198
Stocum, W.E. , and R. G. Hamilton. 1976. "Risk Analysis of Exposure to High Concentrations of Zinc Chloride Smoke." Report SAND-76-0386. Sandia Labs., Albuquerque, NM. Available from National Technical Information Service, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, VA, 22161.

=HC Smokes
+Reaction Products; Chemical Properties; Human Health-Epidemiology; Life Cycle-Use

S1199
Lewis Sr., Richard J., and R.L. Tatken, eds. 1982. Registry of Toxic Effects of Chemical Substances, 1980 Edition. Vols. 1 and 2. U.S. Dept of Health, and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

=General
+Chemical Properties; Physical Properties; Human Health; Mammalian Toxicity-Acute, Chronic, LD50, Inhalation; Carcinogenicity; Mutagenicity; Regulations

S1200
Van Wazar, J.R. 1961. Phosphorus and Its Compounds, Vol. II. Technology, Biological Functions and Applications. Interservice Publishers Inc., New York, NY.

=Phosphorous Smokes
+Life Cycle-Manufacture; Phytotoxicity; Food Chain; Soil Contamination; Water Pollution

S1201
Hodgman, M.S., R.C. Weast, and S.M. Selby, eds. 1959. Handbook of Chemistry and Physics, 41st Edition. Chemical Rubber Publishing Co., 2310 Superior Ave. N.E., Cleveland, OH.

=General
+Chemical Properties; Physical Properties

S1202
Cohn, S.L. 1981. "Transport and Diffusion Solutions for Obscuration Using the XM-825 Smoke Munition." Report ERADCOM/ASL-TR-0100, AD-A109739/3. U.S. Army Electronics Research and Development Command, Atmospheric Sciences Lab, White Sands Missile Range, NM.

=General
+Transport & Diffusion-Models; Munitions-Artillery

S1203
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=HC Smokes; Phosphorous Smokes
+Munition-Artillery, Ground; Transport & Diffusion-Field Data; Physical Properties-Aerosol; Analytic Methods

S1204
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=General
+Munition-Ground

S1205
Dumbauld, R.K., S.F. Saterlie, and C.S. Cheney. 1982. "Analysis of Multiple Source Obscurants on the Realistic Battlefield (AMSORB). Vol. I. Mathematical Models and Computer Program Description." AD-A117663/5. Cramer (H.E.) Co. Inc., Salt Lake City, UT.

=HC Smokes; Phosphorous Smokes
+Transport & Diffusion-Models; Munition-Ground, Mortar, Grenade, Artillery, Tank

S1206
Pankow, J.F., and G.L. McKown. 1975. "Effects of Environmental and Processing Conditions on Composition and Sensitivity of HC White Smoke Mix." Report EM-CR-74053, AD-B004012/1. General Electric Co., Engineering and Science Services Lab, Bay Saint Louis, MO. NAS8-27750.

=HC Smokes
+Reaction Products; Chemical Properties; Physical Properties

S1207
Rohrs, L.C. 1957. "Metal-fume fever from inhaling zinc oxide." A.M.A. Arch. Indust. Hyg. 16:42.

=HC Smokes
+Reaction Products; Human Health-Epidemiology, Clinical

S1208
Nau, C.A., J. Neal, and M. Thornton. 1966. "C9 - C12 fractions obtained from petroleum distillates. An evaluation of their potential toxicity." Arch. Environ. Health. 12:382-393.

=Diesel Fuel Smokes; Fog Oil Smokes
+Munition Composition; Analytic Methods; Mammalian Toxicity

S1209
Rinehart, W.E., and T. Hatch. 1964. "Concentration product (CT) as an expression of dose in sublethal exposures to phosgene." Am. Ind. Hyg. Assoc. J. 25:524-553.

=General
+Mammalian Toxicity-Inhalation

S1210
Melzian, B.D. 1982. "Acute toxicity, histopathology, and bioconcentration-retention studies with no. 2 fuel oil and the blue crab, Callinectes sapidus Rathbun." (Abstract). Dissertation Abstr. Int. 43(11):3448-B. Univ. Microfilms Int., Order No. DA8306410.

=Fog Oil Smokes
+Food Chain-Bioconcentration; Aquatic Toxicity

S1211
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=Diesel Fuel Smokes; Fog Oil Smokes
+Chemical Properties; Physical Properties; Water Pollution; Soil Contamination

S1212
Swiller, A.I., and H.E. Swiller. 1957. "Metal-fume fever." Am. J. Med., 22:173.

=HC Smokes
+Human Health-Clinical

S1213
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=Phosphorous Smokes
+Aquatic Toxicity; Analytic Methods

S1214
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=Diesel Fuel Smokes; Fog Oil Smokes
+Water Pollution; Soil Contamination

S1215
Malins, D.C., W.T. Rouball, and S.I. Stranahan. 1978. "The accumulation of low molecular weight aromatic hydrocarbons of crude oil by coho salmon (Oncorhynchus kisutch) and starry flounder (Platichthys stellatus)." Arch. of Environ. Contamination and Toxicol. 7(2):237-244.

=Diesel Fuel Smokes; Fog Oil Smokes
+Aquatic Toxicity; Food Chain-Bioconcentration

S1216
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=Diesel Fuel Smokes; Fog Oil Smokes
+Chemical Properties; Physical Properties

S1217
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=General
+Transport & Diffusion-Models; Reaction Products; Air Pollution

S1218
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=General; Phosphorous Smokes
+Transport & Diffusion-Models; Water Pollution

S1219
Johnston, W.G., and L.B. Sargent Jr. 1970. "The determination of vapor pressures of low viscosity lubricants from distillation data." ASLE (Am. Soc. Lubric. Eng.) Transactions, 25th Annual Meeting in Chicago, May 4-8, 1970. 13(4):304-10.

=Diesel Fuel Smokes; Fog Oil Smokes
+Physical Properties

S1220
Hansch, C., and A.J. Leo. 1979. Substituent Constants for Correlation Analysis in Chemistry and Biology. John Wiley & Sons, New York, NY.

=General
+Physical Properties; Chemical Properties; Food Chain-Bioconcentration, Uptake

S1221
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=General
+Physical Properties; Chemical Properties; Food Chain-Bioconcentration, Uptake

S1222
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=General
+Chemical Properties; Physical Properties; Food Chain-Bioconcentration; Water Pollution; Soil Contamination; Analytic Methods

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The following five bibliographic lists are provided in order of accession. They include bibliographies of Colored Smokes, Diesel Fuel and Fog Oil Obscurants, General References, HC and Zinc Chloride Obscurants, Infrared Obscurants, and Phosphorous Obscurants. They include all of the information in the full citation except for the identifiers and descriptors. The accession number is provided at the end of each citation.

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GUIDE TO DATA BASE

INTRODUCTION

Early in the data acquisition phase of this project, it became clear that an automated method for the storage and retrieval of information was needed. This need was filled with the purchase of an IBM personal computer equiped with an external 20 megabyte hard disk drive and various software packages. The software included: Lotus 123, Lotus Development Corporation, 161 First Street, Cambridge, MA 02142; IBM Personal Editor, International Business Machines Corporation; Microsoft Word, Microsoft Corporation; KnowledgeMan: The Knowledge Manager, Micro Data Base Systems, Inc., P.O. Box 248, Lafayette IN 47902.

Most of the collected data was entered and stored in tables created under KnowledgeMan. This data base manager allows Boolean searches of all types of data in all KnowledgeMan files. Microsoft Word and IBM Personal Editor were used in many word processing applications and Lotus 123 was used whenever a spreadsheet was required. The following Data Base Description Table is provided for the convenience of those interested in obtaining and using our Smokes and Obscurant Data Base.

DATA BASE DESCRIPTIONS

Nine major tables were created under KnowledgeMan to fill specific needs. The names of these tables are listed in the Base Description Table along with their structure and purpose. They are available from LLNL on 5.25 inch DSDD diskettes in IBM Dos 2.0 format as either ASCII text files or as KnowledgeMan files. These files are also available on Sysgen Image cassette tape, Sysgen Incorporated, 47853 Warm Springs Blvd., Fremont, California 94539, or on Q-PAK 5.5 megabyte hard disk removable media, SyQuest Technology, 47923 Warm Springs Blvd., Fremont, CA 94538.

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